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Environmental Protection Agency

December 1975

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NON-POINT SOURCE POLLUTION SEMINAR

SECTION 108 (a) DEMONSTRATION PROJECTS

(POLLUTION CONTROL IN GREAT LAKES)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NOVEMBER 20, 1975 Chicago, Illinois

REPRODUCED BY
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This report is a collection of technical papers presented at the "Non-Point Source Pollution Seminar" held in Chicago, Illinois on November 20, 1975. The principal investigators of three Section 108(a) projects present their data and interpretation thereof, that has been collected on their respective projects through June of 1975. These projects are sediment/erosion control demonstration projects located in three different watersheds. Black Creek Watershed in Allen County, Indiana; Nemadji River Watershed in Western Lake Superior Red Clay Area; and Menomonee River Watershed in Washington County, Wisconsin.

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SECTION 108(a) DEMONSTRATION PROJECTS PROGRESS REPORTS

NOVEMBER 20, 1975

Held at

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Chicago, Illinois 60604

in

Conference Room 1228

Sponsored by

U.S. ENVIRONMENTAL PROTECTION AGENCY
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INTRODUCTION

This one-day seminar, offered to Federal, State, and local water pollution control officials, scientists, educators, consulting engineers and other interested persons, was designed to provide information from Section 108(a) demonstration projects on non-point source water pollution control. This seminar was held in the Region V office of the U.S. Environmental Protection Agency in Chicago, Illinois.

Key areas of study, accumulated data and knowledge regarding three on-going non-point source pollution studies is evaluated and is contained in this collection of papers presented at this seminar by the principal investigators.

Project data and information reported are from the following section 108(a) demonstration projects:

> Black Creek sediment and erosion control project in Allen County, Indiana. Grantee is the Allen County Soil and Water Conservation District.
>
> Western Lake Superior red clay sediment and erosion control project in the counties of Carlton, Douglas, Ashland, Bayfield, and Iron. The grantee is the Douglas County Soil and Water Conservation District in cooperation with Carlton, Ashland, Bayfield, and Iron County Soil and Water Conservation Districts.
>
> Washington County, Wisconsin sediment and erosion control project involving the Menomonee River watershed. The grantee is the Wisconsin Board of Soil and Water Conservation Districts.

Interim conclusions on work done on the above projects are based on data through June 1975. Cost figures presented on implementing land management practices in the Black Creek project are actual costs incurred with landowners to achieve the projects objectives.

CALL TO ORDER

By

Ralph G. Christensen*

Ladies and gentlemen, I appreciate your attendance here today at this non-point source pollution seminar. I am Ralph G. Christensen Chief of the Section 108a Program under P.L. 92-500. Section 108a provides for grants to support any State, political subdivision, interstate agency, or other public agency, or combination therof, to carry out one or more projects to demonstrate new methods and techniques and to develop preliminary plans for the elimination or control of pollution within all or any part of the watersheds of the Great Lakes. Such projects shall demonstrate the engineering and economic feasibility and practicality of removal of pollutants and prevention of any polluting matter from entering into the Great Lakes in the future and other reduction and remedial techniques which will contribute substantially to effective and practical methods of water pollution prevention, reduction, or elimination. This program requires a grantee to provide a minimum of a 25% matching contribution to the total cost to the project.

Congress authorized to be appropriated $20,000,000 to carry out the provisions of this program. To date, there has been nine grants awarded under this section of the Act, three of which address the non-point source pollution problem.

Section 108 allows the demonstration of new approaches beyond those reflected in state established construction priorities, beyond those developed and demonstrated within the specified scientific and engineering subprograms, and beyond the few basin planning efforts that have been funded in the Great Lakes.

Section 108 implicitly recognizes that the approaches available in other EPA programs may not be adequate for controlling pollution in a basin of the scope and complexity of the Great Lakes system. It recognizes that the water quality of the Great Lakes is of broad national interest that may not be fully considered in setting state and local priorities. In response, it provides opportunities to demonstrate the value of approaches receiving low priority at the state and local level. Section 108 also implicitly recognizes that a piecemeal approach to wastewater management and treatment, while an important immediate step, cannot provide the systematic solutions required by such a large, complex environmental system as the Great Lakes.

Section 108 provides opportunities to supplement the piecemeal approach with system studies, plans, and demonstration projects that

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*Chief, Section 108a Program, P.L. 92-500, United States Environmental Protection Agency, Region V, Chicago, Ill. 60604. Program Chairman.

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broaden the focus beyond the boundaries of specific point sources, specific treatment technologies, and local jurisdictions. For example, Section 108 projects can address the full complexity of the multiple causes of pollution, both point and non-point, within a basin system; or the institutional barriers to arriving at areawide solutions in a politically responsible fashion; or the design of new treatment and control measures combining the results of new technologies and regulatory techniques.

Section 108, however, does not now provide a program of sufficient size to stand alone. It is clear that $20 million of demonstration projects, by themselves, would make little impact on the pollution problems besetting the Great Lakes. Section 108 projects must be used in addition to, in coordination with, and as a testing ground for, the use of authorities and resources available under present legislation. Section 108 provides opportunities to weld together specialized technical advances to yield new systems. It provides opportunities to fund new types of facilities in combination with treatment facilities and demonstrations supported by Section 201 and Section 105 grants. And it provides opportunities to channel these resources in ways that develop and strengthen implementing institutions.

We will now proceed with the Seminar Program, as outlined in your printed Seminar Agenda.

WELCOME
BY
Francis T. Mayo*

We, in the Environmental Protection Agency, appreciate the opportunity to meet with you today and share some practical, social and technical information derived from three Sec. 108 demonstration projects implemented in this Great Lakes area.

The agenda for this Seminar provides for an overview of the Non-Point Source Pollution Control mandate to the U.S. EPA through P.L. 92-500. Several sections of P.L. 92-500 address the subject of non-point source pollution among which are, Sections 208, 303, 304, and 305. In addition to these sections of the Act, Sections 108, 104 and 105 provide for research and demonstration grants which can also address the non-point pollution problems.

Non-point source pollution is recognized internationally as a problem and is being addressed in the Great Lakes under the U.S.-Canada Great Lakes Water Quality Agreement. One of the references of this Water Quality Agreement is directed to inventory land-use activities and their pollution effects on the Great Lakes. To do this, we have implemented four land-use watershed studies in the United States and six watershed studies in Canada to prepare the information and remedial recommendations to best reduce and control non-point source pollution to the Lakes. Region V has committed $12 million to support these Sec. 108 demonstration projects and land-use watershed studies. Additional funds are being awarded in grants to designated Sec. 208 agencies to study and prepare Areawide Waste Treatment Management Plans for implementation.

Russell Train, our EPA Administrator, stated in a recent speech that non-point sources of water pollution, such as runoff from croplands, urban stormwater, and strip mining, are becoming the single most important water quality problem.

Congress placed primary responsibility for the management of non-point source pollution in the hands of the States. This is as it should be. States and localities are better able to identify their problems as part of their over-all planning process than is the Federal government. We want to see localities, acting on a regional basis, getting more and more into the business of really facing up to these issues. Plans for solving such problems would be created and carried out through a political process in which both citizens and their elected officials—not experts or appointed officials—make all the basic choices and decisions. We want to encourage State and localities to tell us at the Federal level how we can help with programs that are conceived and implemented at lower levels.

---

*Francis T. Mayo, Administrator, U.S. EPA, Region V, Chicago, Illinois 60604

To highlight some problems associated with non-point pollution, let me give you some examples:

(1) Two billion tons of sediment are delivered to lakes and streams annually from over 400 million acres of croplands, as well as large amounts of nitrogen from fertilizers, phospohorus from non-point sources, animal wastes from feedlots, and toxic pesticides.

(2) Between 5 and 10 percent of the total sediment load is estimated to come from 10 to 12 million acres of commerical forest harvested per year.

(3) Strip mining, which affects about 350,000 acres annually, results in the discharge of millions of tons of acidity and sediment.

(4) Urban sprawl, which consumes hundreds of square miles per year, generates sediment at an even greater rate than agricultural activities.

(5) The runoff of stormwater in urban areas accounts for pollution of waters with large amounts of toxic and oxygen-demanding materials.

Non-point sources of water pollution have become more than 50 percent of the total water quality problems. As site-specific sources of pollution are reduced by municipalties and industries, other sources gain in relative importance.

As a result of State and local interest three demonstration projects have been implemented under Sec. 108 of P.L. 92-500. These projects will be reported on today by either the grantee project directors and/or their principal investigators. I will describe to you briefly the objectives of each project.

(1) The Allen County (Indiana) SWCD's Black Creek Project has been active now since 1972 and has two years yet to go. This project provides for a cooperative effort between Allen County SWCD, the U.S. Department of Agriculture Soil Conservation Service and a team of scientists and engineers from Purdue University to demonstrate sediment reduction through use of land management practices. A socio-economic study is in progress to ascertain what it will take to get landowners to implement best management practices for erosion sediment control.

(2) Douglas County (Wisconsin) Soil and Water Conservation District is now in the process of implementing their demonstration project in the Red Clay Area of western Lake Superior. The goal of this project is to initiate and implement an action program for soil erosion and sediment control in the Lake Superior Basin which will lead into a basin-wide program. Institutional arrangements and vehicles for intergovernmental cooperation between local governmental implementing authorities on an interstate basis will be established to solve the basin-wide red clay erosion and sediment problems.

(3) The Wisconsin State Board of Soil and Water Conservation Districts is the Grantee for a project in Washington County, Wisconsin. Their project is to demonstrate the effectiveness of land control measures in improving water quality, and to devise the necessary institutional arrangements for the preparation, acceptance, adoption, and implementation of a sediment control ordinance applicable to incorporated and unincorporated areas on a county wide basis.

I hope the progress reports presented today will benefit you in your planning activities. I appreciate your attendance here today. If we can be of assistance to you during the day, please contact Mr. Ralph Christensen or Mr. Joseph Tynsky who will be happy to help you.

THE CHALLENGE TO AMERICAN AGRICULTURE OF P.L. 92-500 FROM A NATIONAL VIEWPOINT - FOCUS ON "POLITICAL RULINGS AS THEY AFFECT NPS PROGRAMS"

By
John R. Churchill*

Good morning. I have been assigned to cover a very expansive topic--the challenge to American agriculture of P.L. 92-500--in a very short time. With regard to political rulings as they affect the nonpoint source program, I suspect that the designer of the program for this seminar was trying to flush me out on the development of recent positions and policies within EPA with regard to recent judicial decisions and statements by the Administrator and the Deputy Administrator. I shall be very glad to bring you up to date on the rapidly unfolding interpretation of several important statutory requirements of the Federal Water Pollution Control Act that affect agriculture.

Let's pause a moment and look at the historical framework in which we are addressing nonpoint sources within the national water quality program. Between 1948, when the first Federal Water Pollution Control statute was enacted, and 1972, the entire water pollution control effort was directed at municipal and industrial point sources. It was not until the 1972 Amendments that the Congress began to legislate to provide tools to deal with nonpoint sources. Now we are beginning to address, in a national, systematic way, the control and minimization of nonpoint sources.

In the water pollution control effort and in the development of solutions to other public issues, we usually go through a four-phased program:

First we ignore, and when that doesn't work;
We make it illegal, and when that fails us;
Congress pulls out its checkbook and we spend it to death, and finally;
We develop a rational approach and solve the problem.

It is through the projects that we are reviewing today and the processes of communication we are developing in this meeting that we will definitely shorten the process I have described above.

In the 1972 Amendments, the Congress developed two different thrusts--one for what has been described as point source pollution and the other for nonpoint sources.

For point sources, which are defined very broadly by statute to include all discharges from discrete conveyances, including ditches, the Congress required us to develop national effluent guidelines and develop a Federal and State program to permit these discharges. They require discharger to apply for a permit or be in violation of the statute.

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*John R. Churchill, Interagency Coordinator, Water Planning Division, United States Environmental Protection Agency, Washington, D.C. 20460

For nonpoint sources, the Congress required the State and local governments through areawide agencies, to develop a plan and a management implementation program to deal with them.

The 208 planning and management program is the central administrative vehicle for both point and nonpoint sources. We have initiated the areawide program and the governors have designated 149 planning and management agencies, and EPA has granted $150 million to finance the initial two-year planning period.

We are about to issue regulations which will require the State to develop 208 programs in non-designated areas. Recently, a circuit court judge ordered us to require the States to come up with such plans and implementation programs by November 1978. This,then, is the major vehicle for planning and management of nonpoint sources and the first step is for the several land management and water quality agencies in the States to join together with other Federal agencies and public interest groups to assess carefully the nature and extent of nonpoint source runoff problems and to develop effective solutions.

Under Section 402 is the National Pollutant Discharge Elimination System (NPDES). The regulations were first promulgated and published in the Federal Register in December 1972. On May 3, 1973, EPA proposed a short form for agricultural discharges and proposed classes and categories of agricultural and silvicultural activities which would not be subject to NPDES permit requirements. On July 5, 1973, after receiving information, statistics, and advice from other Federal agencies, State officials, and agricultural and environmental groups in response to the May 3, 1973, proposal, EPA issued notice of the availability of the final agricultural application Short Form B and published an amendment to §125.4 (38 F.R. 18000). This amendment provides for an expansion of the exclusions in that section, eliminating categories of small concentrated animal feeding operations and certain agricultural and silvercultural activities from the permit requirement.

In promulgating these regulations, EPA stated its belief that most sources within the exempted categories present runoff related problems not susceptible to the conventional NPDES permit program, including effluent limitations. EPA's position was and continues to be that most rainfall runoff is more properly regulated under section 208 of the FWPCA, whether or not the rainfall happens to collect before flowing into navigable waters. Agricultural and silvicultural runoff, as well as runoff from city streets, frequently flows into ditches or is collected in pipes before discharging to a stream. EPA contends that most of these sources are nonpoint in nature and should not be covered by the NPDES permit program.

This position would allow limited administrative discretion in excluding these basically nonpoint sources from the program.

The Natural Resources Defense Council (NRDC) has challenged this exercise of Administrator's discretion in a lawsuit filed in the Federal District Court for the District of Columbia. The District Court ruled in favor of NRDC in what has been known as the Flanery decision. The final court order requires EPA to propose and promulgate regulations "extending the NPDES permit system to include all point sources" in the concentrated animal feeding operation, separate storm sewer, agricultural and silvicultural categories. Under the terms of the order EPA must propose regulations relating to storm sewers and concentrated animal feeding operations by November 10, 1975, and promulgate such regulations by March 10, 1976. Similarly, regulations extended in the permit system to point sources discharges in the agriculture and silviculture categories must be proposed by February 10, 1976, and promulgated by June 10, 1976.

As part of the effort to carry out the requirements of the court order, EPA has solicited and received information and advice from other Federal agencies, State and local officials, trade associations, agricultural and environmental groups and interested members of the public. We have held "town hall" meetings in cities across the Nation. Many of you here today attended the Chicago meeting back in September.

Drawing considerable from the comments received at these meetings and the technical data, legislative history and statutory language, the Agency has selected a regulatory approach.

Under the EPA proposals, a feedlot operator would be required to apply for a wastewater discharge permit if:

—more than the following numbers and types of animals are confined: 1,000 slaughter and feeder cattle; 700 mature dairy cattle (whether milked or dry cows); 4,500 slaughter hogs; 35,000 feeder pigs; 12,000 sheep or lambs; 55,000 turkeys; 180,000 laying hens; 290,000 broiler chickens.

—measurable waste are discharged directly into any navigable waters that traverse the operation, or

—measurable waste are discharged into navigable waters by means of a man-made conveyance specifically constructed for wastewater disposal, or

—measurable waste or otherwise a significant source of pollution.

John Quarles has stated that "The regulations announced today have been drawn up to carry out the express guidance of the Court and the language of the Federal Water Pollution Control Act of 1972. These rules are designed to extend the NPDES permit program to sources within the four categories designed by the court and to continue our mission to improve the quality of our Nation's waters, without interfering with, or placing a great burden on, small farm operations."

The new regulations appeared today (11/20/75) in the Federal Register. As for as the storm water runoff regulations go, we have asked for a three week extension for the due date for the publication in the Federal Register.

As far as section 208, Administrator Train has made it perfectly clear in his speeches before the Conservation Districts in Bettendorf, Iowa, and the American Forestry Association in Washington that "it simply makes no sense to take the Federal regulatory permit approach to many of the sources of water pollution...that the court order would require us to take. By their very nature, they are best dealt with primarily at the State and local level as part of an overall, intergrated approach to such sources based upon best management practices."

His position is that we must develop effective programs that require close cooperation and leadership by other agencies such as the soil conservation districts at the local level, the Extension Service at the State and local level, the Soil Conservation Service at Federal, State and local levels, the Forest Service in national forests and in their technical and financial assistance programs, and the Bureau of Land Management in their land management asd associated community development programs. All these agencies and many others will be vital participants in the 208 planning process.

As Regional Administrator Mayo indicated earlier, the three demonstration projects we are reviewing today under Section 108 are the real prototypes of a 208 program. First, they involve the soil conservation districts' taking the leadership role in bringing together the farmers, other interested publics, the universitites, and the many agencies that have a concern and mission in the 208 program. Secondly, it involves the bringing together of land management, agricultural engineering, aquatic biology, data systems, sociology, economics, law, and the many disciplines that we must fuse together in an appropriate 208 program.

It is now becoming rapidly apparent that water quality is an integral part of the American agriculture mission. The real and definite pollution threat from sediments, nutrients and pesticides must be dealt with. The main thrust of the nonpoint source pollution control will come from 208 areawide planning.

The importance of controlling pollution from agricultural sources was early recognized by Administrator Mayo. The technical information generated from these projects is giving us that which is necessary to make an assessment of the agricultural nonpoint source problem.

I look forward to sharing this learning experience with you and thank you very much.

OVERVIEW OF RESEARCH AND DEVELOPMENT AS IT RELATES TO NONPOINT SOURCE POLLUTION

By

Paul R. Heitzenrater*

Of all the water quality problems facing the Nation today, pollution from non-point sources is technically one of the most complex. Major non-point source categories have been defined to include mining, agriculture, silviculture, and urban storm water. For the purposes of this seminar, I will emphasize agricultural non-point sources. However, note that the types of research we have underway are similar for all of these areas.

The significant components we have identified in the agriculture research area include: waste management from animal production, irrigated corp production, non-irrigated crop production, alternate pest management, and because of some similarities, silviculture practices. Our research program ranges in breadth from production through harvesting and the objectives encompass: a) mathematical simulation models to predict the water quality impact of various agriculture and silviculture practices and, to assess the impact of alternate management methods; b) best management practice (BMP) alternatives designed to reduce or prevent runoff of pollution discharges or emissions which adversely impact air, land or water, including cost-effective determinations and evaluation of social and economic impacts; c) assessment of probable trends in production of renewable resources and their resulting environmental impacts; and d) development of intergrated pest management controls to reduct environmental problems from agricultural pesticides.

We are concurrently attempting to address both long term and short term problems. It is expected that during the last quarter of this century pressure will mount for the U.S. to significantly increase production from the agriculture industry. Environmental problems of a broad scope may well accompany any drastic efforts to increase renewable resources in the U.S. Moreover, significant conflicts may arise between energy development, production and uses, community development, and agricultural resources activities. Hence, the long-term problem for the U.S. will be to increase production of food and fiber with minimal environmental degradation and conflict with other national goals. The Agency's long-term research objectives are: (a) develop the capability to assess and predict the environmental effects of existing and advanced technologies for increasing production of each renewable resource and between resources at the local, regional, and national levels; and (b) develop cost-effective alternative technological, management, and institutional approaches to assure increased production at the least environmental cost.

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*Staff Engineer, Agriculture and Nonpoint Source Management Division, Office of Research and Development, Environmental Protection Agency, Washington, D.C. 20460

The more immediate task confronting the Agency is to provide State and local water quality management agencies with the tools they need to carry out their areawide waste management responsibilities under Section 208, P.L. 92-500. The tools include: (a) guidelines for identifying, assessing, and evaluating the nature and extent of agricultural and silvicultural source of pollution, and (b) processes, procedures, and methods to manage and control pollution from these sources.

The systems by which we product our food and fiber involve not only highly complicated living processes, but these processes very greatly with location. This variation is readily apparent among the major climatic and land resource areas of the Nation. However, it can also be significant on a local scale. The conditions of soil, crop, topography and hydrology and, therefore, the type of pollution controls required, may differ greatly between the fields at the upper fringe of a watershed and those in the bottom lands only a few miles or hundred yards away.

The term "pollutant" is not simple to define as it applies to agricultural sources. The major substances involved, sediment, nutrients and salts, are natural components of the ecosystem which become "pollutants" only when they exceed levels which impair water quality or beneficial uses of our waters. Also, these substances are not discharged in a continuous, easily predicted manner. Their discharges is the result of rainfall or snow melt runoff, which can be predicted with only limited accuracy. Since these discharges are intermittent and often diffuse, there is usually no distinct effluent which can be easily collected or monitored for its quantity and quality of pollutants, the most essential pieces of information needed for environmental management purposes. We are therefore forced to use less direct means for assessing the contribution to water pollution from agricultural sources and for determining the effectiveness of methods for controlling this impact.

In dealing with a problem as complex as water pollution from agriculture, it is tempting to either make the problem more understandable by trying to reduce it to a few generalizations or to bog down completely in its details and diversity. Oversimplification is apparent in attempts such as equating agricultural water pollution control with erosion control or in effects to press for general solutions such as the application of uniform control practices over broad areas such as an entire State. The other extreme is to overcomplicate the problem by emphasizing the complexity and uncertainties of its solution. This appears as "pressure to do nothing" until we fully understand the nature of the agricultural water pollution problem and can fully justify the means for its control.

With regard to agricultural pollution control, one of the key public decisions will be what level of technical information is needed to justify action. In an attempt to be responsive, we have identified several basic questions for which the Section 208 planner - decision maker will need answers.

1. How much of the pollutant or potential pollutant leaves the site where it is generated?
2. How much of the pollutant reaches a location where it degrades water quality or results in some other environmental damage?

3. How much water quality degradation or damage occurs as a result of this exposure level?
4. What options are available for reducting the pollutant load from the source and what is their relative cost/effectiveness?
5. How feasible is the implementation of these control options?
6. Are the benefits resulting from control worth the cost?

It is all but the last question, which can be solved only through the political process, that we must deal with from a technical standpoint.

Where do we stand today in our ability to answer these questions and what is the probability that we will have adequate answers available when they are needed?

1. Measuring Source Loads. The problem here is one of the lack of an effluent which can be easily or economically measured. This means that in most areas we need techniques for measuring something which can be measured, such as soil type, rainfall pattern, cropping procedures, etc., and from these measurements be able to predict the resulting load of pollutants on the nearest body of water. Currently, for some substances such as sediment, we know a great deal about what leaves the source, but considerably less about predicting how much reaches the nearest stream. Similarly, with other substances such as nutrients or pesticides, most of our available data relates to what leaves the source rather than what reaches the watercourse.

EPA's research program is approaching this question in two phases. The first phase is to compile, evaluate and publish what is known now in order to make the current knowledge base widely available. For source loading data an initial effort is being conducted for us by Midwest Research Institute as the first step of a project on the "National Assessment of Water Pollution from Non-point Sources." This consist of a manual of loading factors or functions based on available data for all non-point sources, including agriculture. A draft of this manual is under intense review at EPA and USDA and should be available in January or February 1976. In the meantime, we are printing on a limited basis an "Interim Report" which will be distributed to State and 208 agencies so they can evaluate the types of input that will be needed in order to make the assessments.

The second phase, which is also underway, is the development of more sophisticated loading functions or models which will become available for general use during the period of 1977-1980. Most of these are being developed jointly with other Federal agencies.

Included are:

a. a model for determining salt loads from irrigated agriculture in the Colorado River basin being developed in cooperation with the Bureau of Reclamation.
b. a cropland runoff model for nutrients and pesticides being developed for four major crop regions of the country in cooperation with the Agricultural Research Service.
c. loading functions for animal waste applied to the land in major climatic regions of the country.
d. an initial determination of the feasibility of developing a runoff model for silvicultural activities in cooperation with the Forest Service.

2. Measuring Pollutant Delivery and Damage. This is the problem of determining how much of a pollutant gets to a place where it will do harm and how much damage results. Technically this is probably the most critical problem we face and the one for which useful answers are most difficult to obtain. To understand fully the dynamics of all types of waters in all parts of the country is clearly beyond our current means and the time available, and may not be worth the cost. This problem is a critical one for determining what level of technical information is adequate for decision-making. We do have some very useful information on sediment damages and on acceptable levels of nutrient enrichment in nonflowing waters. However, we need a clearly defined set of measures for decision-making at the local leve. One option we are examining is the possibility of determining background levels of natural substances such as sediment and nutrients in our waters as a measure of acceptable levels. This might constitute the equivalent of a "zero discharge" concept for non-point sources. How one defines and measures "Background" is not straight-forward. However, if it can be done, the concept may have utility in helping to determine acceptable pollutant levels and consequently how far we have to go with agricultural pollution control.

3. Cost/Effectiveness of Source Controls. In this area, we face the problem of knowing a large number of control options but not having adequate information on their effectiveness to improve overall water quality. For example, it appears that soil erosion measures such as no-till farming practices may significantly reduce the pollution load from cropland. However, we do not know with accuracy how much this load would be reduced under most conditions. Also, we have not adequately assessed the significance of possible environmental side effects such as increased infiltration to groundwater or impacts from the increased use of pesticides.

We believe that our initial emphasis should be directed not so much to the development of new control options but to the evaluation of the cost/effectiveness of controls that are available. For instance, if we could relate water quality impact to average annual soil loss we could tap the vast base of knowledge on soil conservation techniques.

Our approach to this area at EPA is varied, but it is aimed both at immediate compilation of known data and longer term demonstrations of cost/effective source management methods. One near-term effort I'd like to mention is a manual of management of pollution from agriculture chemicals, nutrients, and sediments developed for us by the Agricultural Research Service, entitled "Control of Water Pollution from Cropland-Volume I, Manual for Guideline Development", EPA-600/2-75-026a.

This manual, which is keyed to land resource areas, is a guide to selection of agricultural pollution management systems for either a farm or a drainage area. It does not specify what has to be done. What it does do is to describe what data is needed, how and where to get the data, and how to use this data in estimating both pollutant loads and the effectiveness and costs of available controls. The document is aimed at the State and local environmental regulatory official and 208 planners and is not intended to supplant existing information or to discourage the use of local agricultural expertise where appropriate. Rather it is intended to encourage the regulatory official to use available agricultural information and expertise.

4. Implementation of Controls. Sometimes knowing technical solutions to problems is not enough. An example of this occurs with the management of salinity in irrigation return flows from agriculture in the Colorado River basin. Water management methods which involve a substantial reduction of water use while maintaining current crop production will prove to be a highly cost/effective control measure for salinity. However, the implementation of appropriate practices is severely inhabited by existing laws, institutions and traditions. How to best overcome these constraints is not clear at this time.

Assuming we know what needs to be done, how do we go about getting the controls implemented. Certainly changing the way a farmer operates his farm is a far more complicated matter than requiring the installation of a treatment system at the end of a pipe by an industry or municipality. It seems clear to us that our experience with education and persuasion is such that the probability is sufficiently high that some degree of regulation will be required in the public interest.

A major problem in regulating non-point sources is the lack of a defined effluent to measure. With point sources the quality of the effluent, or the pollution load, can be specified as a measure of performance of control systems. By specifying only performance, freedom is provided to select the control system appropriate to the specified source. However, for agricultural sources without an effluent which can be practicably monitored for compliance, the source activities or practices themselves rather than the effluent must be regulated. Hence, it has been suggested that some basic set of commom practices be applied to agricultural sources. However, this concept can be seriously misleading. Agricultural conditions and water quality requirements vary with location to the extent that it may be impractical to attempt to apply uniform practices over large areas. The key to undersatanding this concept is to realize that although the farming practices may in some cases have to be regulated, they will not likely be prescribed by a regulatory agency, and considerable leeway will be allowed for tailoring controls to local conditions. For such a system to work at the local level, there is an obviously critical need for technical guidelines which relate control practices to pollutant loading or performance levels.

CONCLUSION

The Technical aspects of agricultural pollution control are complex indeed. Our challenge in developing a technical base for these critical decisions is made more difficult by the pressures of time. With the lead time for this type of research, we literally have to decide how and commit ourselves to the work needed to produce results three to five years from now. The key to doing this effectively is to understand, with the help of our crystal ball, what technical information the decision-maker will need. I trust this seminar will substantially assist us in this understanding.

USEPA INVOLVEMENT IN MANAGING SECTION 108(a) Projects

By

Carl D. Wilson, Jr.*

The management of all three Section 108 Projects, on non-point sources pollution, by the U.S. Environmental Protection Agency essentially follows the same format. The U.S. EPA project officer is the offical representative of the U.S. Environmental Protection Agency designated to monitor the projects. All activities relative to the project are channeled to or through him.

The grantee or the governing board of the project hires a local project director who is the direct representative of the board and as such, is responsible for the conduct of the project. All technical direction and guidance for the work plan, operations manual, construction plans and specifications, analytical work, evaluation of plans, reports, voucher preparation, and time schedules are channeled through him to the U.S. EPA project officer.

At the initial stage of the project the project officer meets with the grantee and outlines procedures for accounting, preparation of plans and specifications, reports, purchases, assurances and reimbursement procedures. Once the work plan and operations manual have been approved no changes will be authorized without the approval of the local project director and the U.S. EPA project officer.

Project officer assistance is given to the grantee to assure the objectives of the work plan are met. This also includes any additional conditions set forth in the offer and acceptance documents.

All construction plans and farm plans are reviewed by the U.S. EPA project officer for approval. If approval is given after review of the final plans and specifications the project officer will notify the grantee of approval to advertise for bids.

The U.S. EPA project officer reviews the bid tabulations, proof of advertising, and other necessary assurances before granting authority to award construction or equipment contracts. Approval must be obtained from the project officer before a contract can be awarded to the low or lowest responsible bidder.

Authorization must be obtained for the proposed purchases for articles, supplies, equipment and services having a unit value exceeding $1000.00.

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The obtaining of a grant does not in itself constitute prior approval, even though these were itemized in the application for a grant.

The U.S. EPA project officer will perform inspections and program reviews and provide technical assistance to the project. He certifies that the costs included in a voucher, were necessary to the conduct of the project, the amounts claimed are reasonable, and all required reports were received and are satifactory.

At the end of the project the project officer will request an audit of the project account so that final payment can be made.

The final report from the grantee will follow the format set up by the U.S. EPA project officer and approval granted before the report is submitted to the Regional Administrator for distribution and grant completion.

CONSERVATION FARM PLANNING

by

Thomas D. McCain[1]

ABSTRACT

Conservation planning involves a presentation of treatment alternatives by the planner, and a close relationship with the decision maker, the landowner.

WHAT IS PLANNING

Webster defines planning as: devising a scheme or program for doing something; or developing a method of proceeding. With this definition in mind, we can associate planning in our daily lives as an act by someone to develop a systematic method of developing almost anything we want to improve.

The daily drive to our office, school or market takes us across roads planned by specialists trained to recognize certain needs of safe and adequate traffic movement. The placing of man on the moon, the development of the Alaska pipeline, and so on, are all part of plans developed by planners.

Decisions are predetermined for average citizens, in high level planning as just cited in these examples. Planners may therefore put together a master plan at a high decision making level and the individual must accept this as the best course of action. At least this is the way some forms of planning may be conducted. However if planning is to be most responsive to the people, plans must have cooperative imput from the users.

Plans thus developed entirely at the top levels and imposed on users who have no opportunity to present their views must be applied with regulation or force. Planners have a responsibility therefore to project an overview and provide technical continuity to the user but allow the outcome to be a realistic decision by the people themselves.

SELECTING A NON-POINT SOURCE MODEL

The Black Creek Sediment Control Project involves 12,000 acres of diverse landscape in northeastern Allen County, Indiana. Located less than 10 miles from the Indiana-Ohio state line, this "mini-model" of the Maumee basin was selected in December 1972 by a team of researchers, engineers, agronomists and planners. Land use, soil types, topography, farming operations and other watershed runoff characteristics were compared carefully with the 4 million acre Maumee basin before final selection of this agricultural sediment control model.

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An intensive study of Black Creek watershed began in early 1973 to determine the soil conservation treatment needs, the makeup of landowners and tracts, and the development of a program to accelerate land treatment in this selected watershed. A rapid expansion of conservation planning and application efforts had to be devised for this area involving 200 individuals with land holdings of 5 acres or more. In the short period of 5 years an effort to plan each farm and apply all needed land treatment was to be attempted.

PLANNING WITH INDIVIDUAL FARMERS

Just as there are not two individuals alike, neither are two farms alike. First of all, farmers acting responsibly as businessmen and citizens are very individualistic - they want and frequently do make firm decisions. Their agricultural operations vary by the type of land they farm, their livestock enterprises, their available equipment and labor, and most important - the MAN in MANagement.

Accomplishing a high percentage of land treatment in Black Creek watershed involves selectivity in planning. Initially key farmers were selected on a basis of their past cooperative interest and land treatment applications. Early planning efforts were directed toward these people. The progressive farmers are quicker to accept the new programs and accomplish new practices quickly.

Motivation of the individual to really want a conservation plan involves stimulating his interest or curiosity in doing something that will improve his farm, make him a better income or satisfy his desire to sharpen his ability to complete in the independent business of farming.

To be a successful conservation planner, first we must motivate ourselves.

1. We must believe in conservation
2. We must like to work with people
3. We must understand our program
4. We must recognize alternatives
5. We must establish realistic goals, and
6. We must assume leadership

Working for the Soil Conservation Service can provide job motivation through our desire for achievement, recognition, advancement, responsibility and the work itself - for land's sake!

In analyzing the farm we must discover what will motivate the farmer. Why might he even want or feel he needs a farm plan. Is he wanting:

1. To control erosion or sedimentation
2. A balanced crop rotation
3. A planned fertility program
4. A water management disposal system
5. To reorganize field layout
6. To change his livestock program
7. A pond for recreational use, or
8. To improve his land value and beauty

The motivated farmer and planner working together cooperatively can accomplish these goals. Conservation planning is a decision making process on the part of the farmer - not the planner. The trained conservationist is the catalyst needed to provide the technical resource data and the overview necessary to see the forest and the trees at the same time.

CONSERVATION PLANNING TOOLS

The most basic tools used by the planner are the aerial photograph and soil maps prepared for a farm. This overview of the farmer's land provides a better perspective for analyzing field layout, existing drainage and erosion control systems, and soil resources.

The Soil Conservation Service uses an agricultural land classification system to rank soils by the degree of hazards. Land capability units I thru IV are found in Black Creek watershed indicating the presence of land with little or no limitations for agricultural uses (Class I) thru land with severe limitations for use as cropland (Class IV). Most of the latter should be used as pastureland, woodland or wildlife areas.

Subclasses of capability units II and III separate recognized major hazard as: "e" erosion; "w" wetness; and "s" droughtiness. Class II makes up the largest land capability unit with the wetness subclass found predominately in the southern half of the watershed and the erosion subclass mostly in the rolling uplands of the northern half of this watershed.

The only soils with a droughty hazard occur as Class III along the sandy beach ridge traversing midway across the watershed. The highest level of Glacial Lake Maumee occupied most of the southern half of this watershed 12-14,000 years ago. This land makes up part of the area known to early settlers as the Great Black Swamp. These very heavy clay soils accounts for the severe wetness associated with Class IIIw land.

THE UNIVERSAL SOIL LOSS EQUATION

Treatment alternatives for cropland having an erosion hazard are developed for Black Creek cooperators by using the UNIVERSAL SOIL LOSS EQUATION (USLE). Adequate treatment will, at a minimum, control soil loss within the tolerable limits for each soil type and erosion group.

Planners have access to soils information for each farm as they work with the land users in developing cropping systems capable of holding the average annual soil loss to levels within the tolerable limits. Many times a combination of management practices such as: crop rotations, residue use, minimum tillage, contouring, strip cropping, etc., must be combined with one or more mechnical practices: diversions, terraces, grass waterways, etc., to reduce slope length in accomplishing the soil loss goal on each farm.

Most soils in the Black Creek area have annual tolerable loss limits of 3-4 tons depending on their inherent ability to retard erosion. The more erodible (heavier clay) soils have a lower "T/K" index. This coupled with on-site slope data and the rainfall factor for Allen County assists the planner in computing the cropping management factor. This final numerical "C" value is used in selecting the rotation most nearly meeting the needs of the farmer and the soil.

The UNIVERSAL SOIL LOSS EQUATION is: A = RKLSCP

"A" is the computed soil loss per year per unit area of land. It is computed as tons per acre.

"R" is the average annual rainfall erosion index, or the average annual erosive force of rainfall. An R value of 160 is assigned to Allen County, Indiana. R values are found on Figure 2.1.

"K" is the soil erodibility factor. It is a measure of the rate of which a soil will erode expressed as tons per acre per year per unit if R for a 9% slope 72.6 feet long is under continuous cultivated fallow. K values for the soils are found in Figure 2.2.

"L" is the slope length factor. It is the ratio of soil loss from a specified slope length to that from a slope length of 72.6 feet long, which is the slope length for the K value in the equation. A slope length of 72.6 feet long has a factor value of 1. L is determined in the field.

"S" is the slope gradient factor. It is the ratio of soil loss from a specific slope gradient to that from a gradient of 9%, which is the slope gradient specified for the K value in the soil loss equation. A slope gradient of 9% has a factor value of 1. S is determined in the field.

"L" and "S" are usually handled in combination. The soil loss ratio - SL, can be read directly from the slope effect chart, Figure 2.3.

"C" is the cropping management factor. It is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from the land in continuous fallow. Continuous fallow has a factor value of 1 in the equation.

Cropping management factors "C" for common rotations used in Black Creek are found in Figure 2.4.

"P" is the conservation practice factor. It is the ratio of soil loss from a specified conservation practice to that from up-and-down hill tillage operations. Up-and-down hill tillage has a factor value of 1 in the equation.

Table 2.2

Percent Slope	Practice Factor Value		
	Contouring	Contour Strip Cropping	Terracing Plus Contouring
1.1 - 2.0	.6	.3	.6
2.1 - 7.0	.5	.25	.5
7.1 - 12.0	.6	.3	.6
12.1 - 18	.8	.4	
18.1 - 24	.9	.45	

Soil loss tolerance (T) is not found in the equation but is important to the use of the equation in practical field application. It is the maximum soil loss in tons per acre per year which can be tolerated on a specific soil and still permit a high level of crop production to be sustained economically and indefinitely. This does not necessarily equate to water quality levels in streams.

"T" amounts, in tons per acre per year, have been established for all soils in Black Creek and are found in Table 1, together with the K values for the soils. T/K values are also listed in the table. The T/K value is simply the T value divided by the K value for a specific soil. These elements are used as a T/K value on the calculator for Planning Conservation Systems.

USING THE SOIL LOSS SLIDE RULE

The soil loss calculator is used in combination with the reference tables listed to determine proper land treatment alternatives.

As an example, a cropping system computed on Joe Graber's farm in the rolling uplands along the western edge of Black Creek watershed has 5% slopes in field #2 with average slope lengths of 90 feet. The T/K value for this moderately eroded Morley silt loam soil is 7. Joe farms generally across the slope nearly on the contour. The slide rule indicates the cropping value of 0.165. Using his present crop rotation of row-small grain-meadow-meadow (1-1-2) with spring plow and removing silage from the corn ground, his actual cropping factor is 0.060. Therefore averaging the soil loss over this 4 year rotation, Joe could expect a loss of only slightly over 1 ton per acre compared to the tolerable limit of 3 tons to maintain productivity of his land.

Another example is on Duyane Amstutz's farm, where his rotation is a 2-1, that is, 2 years row crop, 1 year wheat and fall plow. On the east part of field 1 we have an area with 2-6% slopes averaging 500 feet long. Field #1 is shaped like a concave bowl, making farming cross-slope or nearly contour not difficult but ineffective as far as soil loss is concerned. A small portion of the field has 6-12 percent slopes. The T/K value of this moderately eroded Morley silt loam is 7. The slide rule indicates a value of 0.048. Using Duyane's present rotation of 2-1 with fall plow his crop factor is 0.264. Therefore, the soil loss averaged over a 3 year rotation is about 16 tons annually per acre.

Since altering any one or a combination of factors in the soil loss equation can bring about favorable results, the cooperator, after considering all the alternatives, decided to break down the slope length by using grassed backslope parallel terraces. By installing these on 170 feet intervals his soil movement (loss) is reduced to just under the 3 ton tolerable loss limit. These terraces temporarily pond runoff behind each ridge,letting the silt settle in place while "clean" water is going out through a field tile. This tile outlet, of course, helps drain the land after the surface flush has past.

A third example is on Ed Jones' farm located in the lower portion of the watershed, near the point where Black Creek outlets into the Maumee River. The major soil type is Nappanee, which is a nearly level, deep, somewhat poorly drained, depressional soil with a T/K value of 6. Conventional tillage (plow and disc) is performed generally up and down the slope which is 2 percent with a length of approximately 450 feet. Henry fall plows all his corn ground, The cropping management (slide rule) factor for this land is 0.85. This factor would limit his cropping rotation to a 1-1-1 (or 1 year row crop, one year small grain, and one year hay or pasture). Henry elected to not fall plow but leave the 4000-6000 lbs. of corn stalk residue from the 120 bushel average yield on the soil surface during the erosive winter and spring months and use minimum tillage (chisel plow with one discing) in the spring. With this change in management techniques he can now safely go to a 3-1x rotation (3 years row crop, 1 year small grain with clover intercrop) and still be within the allowable soil loss for this soil type. Prior to this change in cultural practices Henry was loosing on the average approximately 11 tons of soil per acre per year on the same ground.

PLANNING ALTERNATIVES BECOME DECISIONS

As the planner secures the basic cropping data and computes the rotational alternatives, the real test of salesmanship and motivational methods must be employed. At this point the plan is a series of alternatives that require cooperator decisions. To secure the final decisions the planner will:

1. Utilize curiosity and encourage its development
2. Focus attention toward desired outcomes
3. Use existing interests and develop others
4. Provide concrete and symbolic incentives if necessary
5. Provide for realistic goal setting, and
6. Aid in evaluating progress toward meeting goals

Black Creek plans nearly always result in contracts between the landowner and the Allen Soil and Water Conservation District. To become a contract all decisions necessary for controlling erosion to within tolerable limits must be made and recorded. The SWCD will then allocate funds for the contract period according to a plan of operations. Modifications can be made to add, delete or revise amounts planned. However, these changes must again be reviewed and approved by the Board of Supervisors.

If a farmer desires not to complete all decisions, SCS can prepare the conservation plan with alternatives noted. The farmer has a copy of his plan but does not have the advantage of cost-sharing incentives. If he later elects to complete all decisions he is eligible for a contract. However he may also complete his plan and have the full service of the SCS technicians on the basis of his plan even though there is no cost-sharing involved.

Occasionally an individual may have not become interested in a plan during the initial contact. In those cases a different planner with a slightly different approach may be able to stimulate a desire for a plan. We realize however that 100% acceptance of the cooperative planning approach will never be accomplished in the Black Creek project. Some of these unapproachable landowners may be the ones we most need to complete a meaningful land treatment program.

COMPLETING THE PLAN

In summarizing the objectives and methods of farm planning, the farmer must be stimulated to desire a plan. We do this by developing an understanding of his resources:

1. We will illustrate differences in land use and the problems and potentials it creates.
2. Provide a service in interpreting soil capability maps and soil tests.
3. Show an interest in his farm by walking over the land with him.
4. Point out specific problems that are affecting his operation and provide alternative solutions.
5. Provide an overview of off-site damages due to flooding, and siltation from his farm or neighboring lands, and
6. We provide a record of his decisions in a plan showing his potentials and possiblities.

No plan is complete if it is finished, filed and forgotten. The motivated cooperator continually responds to follow-up contacts. We must perform a compliance check once each year. However we will likely see him many times during the year. Each time we visit a farm, whether it is to discuss an upcoming application project, or to determine maintenance of existing practices, we can let a little " conservation enthusiasim" rub off on him. It helps to get him to set a date when we should return. We also can secure definite committments for:

1. Engineering plans needed in advance
2. Technical assistance for practice establishment
3. Scheduling consultation with other specialists

In accomplishing the land treatment planning and application goals for Black Creek watershed we in SCS are constantly aware of our front line approach in carrying out the objectives of many agencies, organizations, and outside water quality interests. We must maintain our relationship with the people. As planners and technicians it is indeed a pleasure to see the fruits of our labors unfold before our eyes.

IMPACT OF SOCIAL ATTITUDES ON MANAGING THE ENVIRONMENT

by

R. M. Brooks and D. L. Taylor*

ABSTRACT

The sociological component is a very important part of the development and maintenance of programs of sediment control. While the initial costs may seem rather high, they will be negated by both the short- and long-term benefits which will be realized. Assessment of the attitudes of the landowners and the social structure of the community allow project personnel to establish early contact with (1) those who are most receptive to the purposes of the project, and (2) those who will have the most influence on other farmers in the area. Data on the attitudes of the farmers and the community structure is reported, and the special problems generated by the nature of the Amish community are discussed.

* * *

The majority of papers in this seminar represent some technical aspect of the various projects funded by EPA to reduce erosion of agricultural land. Some of you may wonder what role sociology can play as a contribution to the success of the Black Creek project. We believe that thus far, the sociological component not only is a valuable addition to a demonstration project, but furthermore is a real first in an attempt to consider something other than a physical component in the reduction of sediment. What we present today will not be the results of several years of study over a range of research projects. Instead, it will be a discussion of what we have found relative to the social component in this project. From this, guidelines can be suggested for future projects to ensure that local people have an input to decisions affecting how they will manage the environment.

A social component is extremely vital in any program of sediment control. This is not to degrade the importance of technology, new machinery and techniques in suggesting alternative approaches to conservation of agricultural land. Yet, after the project terminates, there must be some way to maintain the involvement of those left behind. Without some assurity of commitment to the maintenance of conservation practices, the technical work, regardless of how advanced, will be in vain.

If involvement of landowners is an important component in managing the agricultural environment, then we ought to know something about their perceptions of pollution and its control. Furthermore, a thorough understanding of (1) current agricultural practices, (2) extent of commitment to farming, and (3) the social situation influencing landowners can contribute significantly to the success of a demonstration project such as that in the Black Creek.

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Ultimately, the question of enforcement will arise. Because of existing regulatory practices it is relatively easy to enforce standards on industry merely through lawsuits. Likewise, cities can potentially be brought into compliance by applying pressure to those in political offices who are responsible for resolving such problems. The situation with private landowners, however, is somewhat different. No one individual, organization, state, county or township official has the authority or responsibility to manage landowners. Therefore, enforcement may be more limited. We believe, however, that by operating through the existing social structure, we can utilize local leadership to gain legitimation of the project among landowners.

Without the addition of a social component, evaluation of the success of the project would be tenuous. For example, if the project were to fail, it would be difficult to ascertain whether it failed due to inappropriate equipment, or because landowners lacked an understanding of how to use it. If a demonstration plot were to fail, it might be due to bad weather. On the other hand, it might be because landowners were randomly selected, rather than using relevant sociological criteria--and such farmers might not be as commited to the project. Much of the data needed by other scientists working on the project can only be obtained through personal interviewing of the landowners. For instance, actual fertilizer usage in terms of kind, amount, frequency of application, and manner of application seems to be critical data needed in evaluating the contents of water quality studies. The same rationale would apply to pesticide and herbicide usage. Although aerial photographs are helpful in specifying present crops, future crop plans and agronomic practices can only be obtained by someone skilled in the behavioral sciences. Finally, experiences with various conservation practices again can only be obtained through personal interviewing.

JUSTIFICATION OF SOCIAL COSTS

A difficult part of adding a social component is the costs compared with the benefits of the overall project. One criticism is that there is no visible output. That is, no equipment or machinery is designed to serve similar purposes in other project areas. The process is also time consuming, with little output to help in guiding the project. By the time inputs are made, the project has been terminated. In reality, the social component should be started before the project is in force to begin providing guidelines for directing interaction with key landowners throughout the project.

Personal interviewing is expensive, usually between $30-$50 per inteview. This can be costly when interviewing 300-400 landowners. Yet, we think nothing of making expenditures for rainulators, automatic sampling devices, fully automated analysis machines, tillage equipment, etc.---all important to the work of other scientists on the project. Rather, our criteria for inclusion well might be:

1. What are the present attitudes, beliefs and knowledge base of local landowners and how can we interface with them to change behavior?
2. What is the existing power structure among landowners in the project area and how can it be utilized to introduce conservation practices to local landowners?
3. If pollution control boards were to be organized as a means of regulating erosion on agricultural land, what would be the composition of such a board that would be acceptable to local people?

In other words, how can local people be involved, and how will this help reduce the use of forced compliance? If the social component helps us identify leaders and relevant public attitudes, it may well be worth the expenditure.

POTENTIAL BENEFITS FROM A SOCIAL COMPONENT

In the Black Creek Project, the social component was added in the early stages. However, this was not done early enough to provide a pre-assessment of attitudes, beliefs, and opinions of leaders--nor the existing social structure and networks of social interaction. It would have been helpful if such information could have been obtained prior to any construction in the project area. Why is this beneficial? Many conservation practices introduced ty the project were not new to agriculture but may have been new to the area and/or local landowners. Although the project duration is five years, nevertheless, this is a short period to introduce practices, obtain farmers' cooperation, follow up on unexpected changes in farmers' behavior with respect to conservation plans, and continue monitoring changes in attitudes.

We know, sociologically speaking, that when people live in close proximity certain norms of accepted and unaccepted behavior emerge. Over time, these norms become part of the patterned behavior. In effect, this behavior becomes part of a social system. If we can identify the structure of that social system, then we ought to be able to interface the project goals with the generally accepted patterns of behavior for that area. Furthermore, in that social system, over time, opinion leaders emerge who are known to local landowners, and a majority will look to the leaders for new ideas, acceptance of conservation practices and general approval of their behavior. Let us give some examples of how this might work:

1. Locating cooperators--In most demonstration projects, locating cooperators is a key element. Selecting cooperators that do not fit into the existing patterns of social interaction within the project area can have negative impacts. A landowner who never used an innovative practice on his land may be viewed by other landowners as either eccentric or "odd", if all of a sudden he has multiple practices introduced on his land--even if those practices are agronomically sound.

2. Locating soil types--Since the project is looking at reducing sediment loss, obviously soil types and crops presently on those soils are important. These leaders can use their land as a pool to give access to a cross section of soil types and crops or they can serve as a means of identifying other farmers in the area that have particular soils suitable for specific practices.

3. Developing demonstration plots, tillage plots and field days--A problem in any demonstration project is finding sufficient numbers of farmers that are willing to commit their time and some of their resources to maintaining plots. Location is important, but commitment by the local landowner is more important. Furthermore, frequent field days and project reviews require a landowner that is willing to meet with busloads of visitors and allow frequent interruptions of his daily work schedule.

4. Acquiring equipment--Identifying local leaders opens new doors in the area for additional resources. These leaders usually belong to several professional, business or community organizations and can help in locating specific equipment needs to maintain tillage plots and other conservation practices. This reduces the cost to the project (by not having to purchase the equipment) and increases the involvement of local people.

5. Insuring future maintenance--identifying local leaders introduces project personnel to an accepted group of local landowners that may serve to develop new patterns of organization that would help maintain the practices once the project terminates.

We cannot expect the SCS, SWCD, Agronomists, Agricultural Engineers, Chemists or Biologists working on the project to have this kind of expertise. Furthermore, if the social component is not introduced until later in the project, or even at the same time the project starts, the wrong people may be asked to assume key local involvement (e.g., have tillage plots, etc.) which can cause difficulties later on. Without the social component, we run the risk of expecting great things to come from the uninterested non-leaders rather than trying to locate the interested leaders that can help the project become successful. Although the social component was added a little late in the Black Creek Project, nevertheless, we were able to gain sufficient information to help guide the project. Ideally, however, we feel the social component should begin at least six months prior to any on-site work.

ATTITUDES OF LANDOWNERS IN THE BLACK CREEK

In the winter of 1972 and early spring of 1973 we initiated a survey among landowners in the Black Creek. Criteria for inclusion was that the landowner live within the 12,000-acre project area and be responsible for 10 acres or more. The interview took approximately two hours to administer. Of the landowners in the Black Creek, 1/3 were Old

Order Amish farmers that maintained traditional methods of agriculture. Specifically, this meant that only horse-drawn equipment was used. The non-Amish landowners ranged from full to part time farming. We have included a brief section on some of the general attitudes of landowners in the Black Creek. We expect to use the data as a bench mark to measure change in attitudes over the duration of the project.

The attitudes of landowners are presented in three parts. Part One is a discussion of the general level of awareness of soil conservation, causes of pollution, and pollution control. Part Two looks at the costs associated with preventive measures and future appropriate action. Part Three focuses on attitudes toward pollution control programs and specifically the Black Creek project. An elaboration of these attitutdes can be found in the 1975 Annual Report of the Black Creek Project.

General Awareness

Farmers were asked to respond to two statements: "Conservation of soil is not a real problem in this area." and "Pollution of streams is a major problem in this county." Tables 1 and 2 present responses to these questions by the Amish and non-Amish landowners. An equal percentage of Amish and non-Amish feel conservation of soil is not a problem in the area; whereas 25% feel that pollution of streams is not a major problem (Table 2). In both Tables 1 and 2, the Amish represent a major portion of the "don't know" (DK) responses. Because of their horse-and-buggy form of transportation, the Amish are unlikely to do much traveling throughout the area, other than what is necessary to maintain their simple way of life. There, thus, appears to be sufficient reason for educational programs concerning the awareness of soil problems in the area.

Costs of Pollution Control

A major concern of landowners and federal agencies is how to pay for pollution control. According to our data, both Amish and non-Amish feel that money should be spent for pollution control. In Table 3, over one-half of the non-Amish and almost half of the Amish indicated the cost should not be borne by those whose land is affected. However, at least 20% of both Amish and non-Amish feel that the landowner should bear the cost.

When asked who should pay for pollution control, (Table 4) 40% of the non-Amish landowners expect the federal government to pay 25-50% of the total cost. The landowners also indicated they expected the state and local level to each contribute 25% of the cost. There is some disagreement, however, on how this money is to be raised. Table 5 suggests 40% of the landowners are in favor of federal taxation and 42% opposed to this form of raising revenue for pollution control. There seems to be a general favorable attitude toward government involvement, yet the only way the government can get funds is through taxation.

Black Creek Project

The majority of landowners in the Black Creek (both Amish and non-Amish) feel they will benefit from the project. A large percentage of

Table 1. Conservation of soil is not a real problem in this reea.

	Amish		Non-Amish	
	N	%	N	%
Agree	15	46.9	26	45.6
DK	7	21.9	3	5.3
Disagree	10	31.2	28	49.1
TOTAL	32	100.0	57	100.0

Table 2. Pollution of streams is a major problem in this county.

	Amish		Non-Amish	
	N	%	N	%
Agree	6	18.8	30	52.6
DK	14	43.8	11	19.3
Disagree	12	37.4	16	28.1
TOTAL	32	100.0	57	100.0

Table 3. The cost of soil erosion reducing practices should be borne entirely by those whose land is affected.

	Amish		Non-Amish	
	N	%	N	%
Agree	7	21.9	18	31.6
DK	10	31.3	6	10.5
Disagree	15	46.8	33	57.9
TOTAL	32	100.0	57	100.0

Table 4. Who should pay for the efforts in this district to control pollution? Indicate the percentage of payment by eafh group.*

	TYPE OF PAYMENT					
	Federal		State		Local	
Percentage	N	%	N	%	N	%
0-25	9	11.2	24	26.9	22	24.7
26-50	35	39.4	21	23.6	19	21.3
51-75	1	1.1	--	--	1	1.1
76-100	--	--	--	--	3	3.3
DK	10	11.2	10	11.2	10	11.2
N/R	2	2.2	2	2.2	2	2.2
TOTAL	57	100.0	57	100.0	57	100.0

* The Amish were not asked this question.

Table 5. Federal taxation to clean up the water wouldn't be too expensive to consider.*

	Non-Amish	
	N	%
Strongly Agree	3	5.2
Agree	20	35.1
Neutral	8	14.0
Disagree	24	42.1
Strongly Disagree	1	1.8
No Response	1	1.8
TOTAL	57	100.0

* The Amish were not asked this question.

Amish were undecided, suggesting that the project was in its early stages and farmers could not estimate the benefits until they had a chance to experience some of the practices. There is strong support for technical and professional people being involved in the program (Table 6) and, furthermore, landowners overwhelmingly gave support for the involvement of the federal government in local soil conservation programs (Table 7).

Identifying the benefits to the farmers' soil conservation is a difficult task. Some of the conservation practices are short run, many are long run; hence there is some skepticism on the part of the landowner about sharing expenses. Time is a critical factor to a farmer. He knows how long it takes to prepare his fields. Therefore, asking him to take on practices that take more time introduces a factor that cannot guarantee any economic benefits, at least in the short run. Furthermore, the level of unawareness of pollution problems, as presented in this section, further hinders landowners in accepting conservation practices. We do have evidence, however, that often times the landowner has the inclination to do something about his conservation problem . Generally, however, he lacks this know-how and does not know where to turn for help. An example of this is one Amish farmer who has a severe washout problem in a creek crossing his land. Every year he would haul several loads of dirt to fill the erosion. After the first rain, it wolld all wash downstream. Fortunately, he has now sign d a contract with the SWCD and the problem will soon be solved.

In summary, Black Creek landowners want government involvement; in fact, they expect it. These landowners lack a thorough understanding of pollution and its causes, as well as means to control it. Finally, the total cost needs to be shared by several levels of government in addition to the local landowner.

LEADERSHIP STRUCTURE AND CHARACTERISTICS AMONG THE NON-AMISH

Earlier, we suggested that identifying the leadership structure in the existing social system would be a means of giving support to the project activities. The rationale behind this is to develop a small but influential group of landowners that are already socially accepted by the majority of landowners, and use this group as a mechanism of support. Each non-Amish landowner was asked to name a local farmer whom they believed was generally "well respected for his agricultural practices". They were then asked to indicate whether or not they had ever gone to that person for agricultural advice. In this manner, we were not only able to ascertain the farmers' believe regarding "knowledgeables" in the area, but to also measure their behavior as approduct of their beliefs. The responses to these two questions are presented in

Table 6. Most of the major decisions in the demonstration project should be made by people with professional and technical training in water and soil management.*

	Non-Amish	
	N	%
Agree	39	68.4
DK	6	10.5
Disagree	12	21.1
TOTAL	57	100.0

* The Amish were not asked this question.

Table 7. The federal government should play an important role in soil conservation programs in this country.

	Amish		Non-Amish	
	N	%	N	%
Agree	20	62.5	36	63.2
DK	10	31.3	6	10.5
Disagree	2	6.2	15	26.3
TOTAL	32	100.0	57	100.0

Figure 1, and represent the non-Amish community within the watershed.[1]

The arrows in the sociogram (Figure 1) are meaningful. A thin arrow indicates the respondents' choice of an opinion leader, but that the respondent did not go to him for advice. A thicker arrow indicates that not only did the respondent believe this person to be well respected, but also that he had gone to this landowner for advice. It should be noted that in the sociogram, the size of the circles have been adjusted to be indicative of which farmers were chosen by the most respondents, with the largest circles being those persons chosen most often.

The two questions on which this figure is based serve two different functions in assessing the social relationships within the community. The first question determines which farmers are well respected. It is a measurement of the social structure of the community. Furthermore, it enables one to identify those persons who hold the most influential and important positions in the community. The second question allows the assessment of the closeness of the relationship between the respondent and the person he chose. In summary, while the thickness of the arrows indicate the interpersonal relationships, the position of the arrows indicate the social structure of the non-Amish farm community.

This information is important to the project because eight key farmers have been identified to aid in the progress of the project. New ideas, as well as the introduction of conservation practices, can be presented to them in an effort to speed up the process of participation in watershed activities. It is important to recognize the existance of a social structure and operate within it. Although the Amish did not respond to these questions of leader identification, nevertheless, they have a social structure in their community that must be recognized if any degree of success is to be expected. The Bishop is a key figure in the Amish church district. Without his approval, little can be accomplished. With his approval, meetings can be scheduled and cooperation anticipated. It is important to know and understand these two systems and how they affect working relationships among landowners.

To serve as a cross-check on the validity of the data displayed in the sociogram, farmers were asked to select people to serve on a pollution control board. Each respondent provided the names of three people

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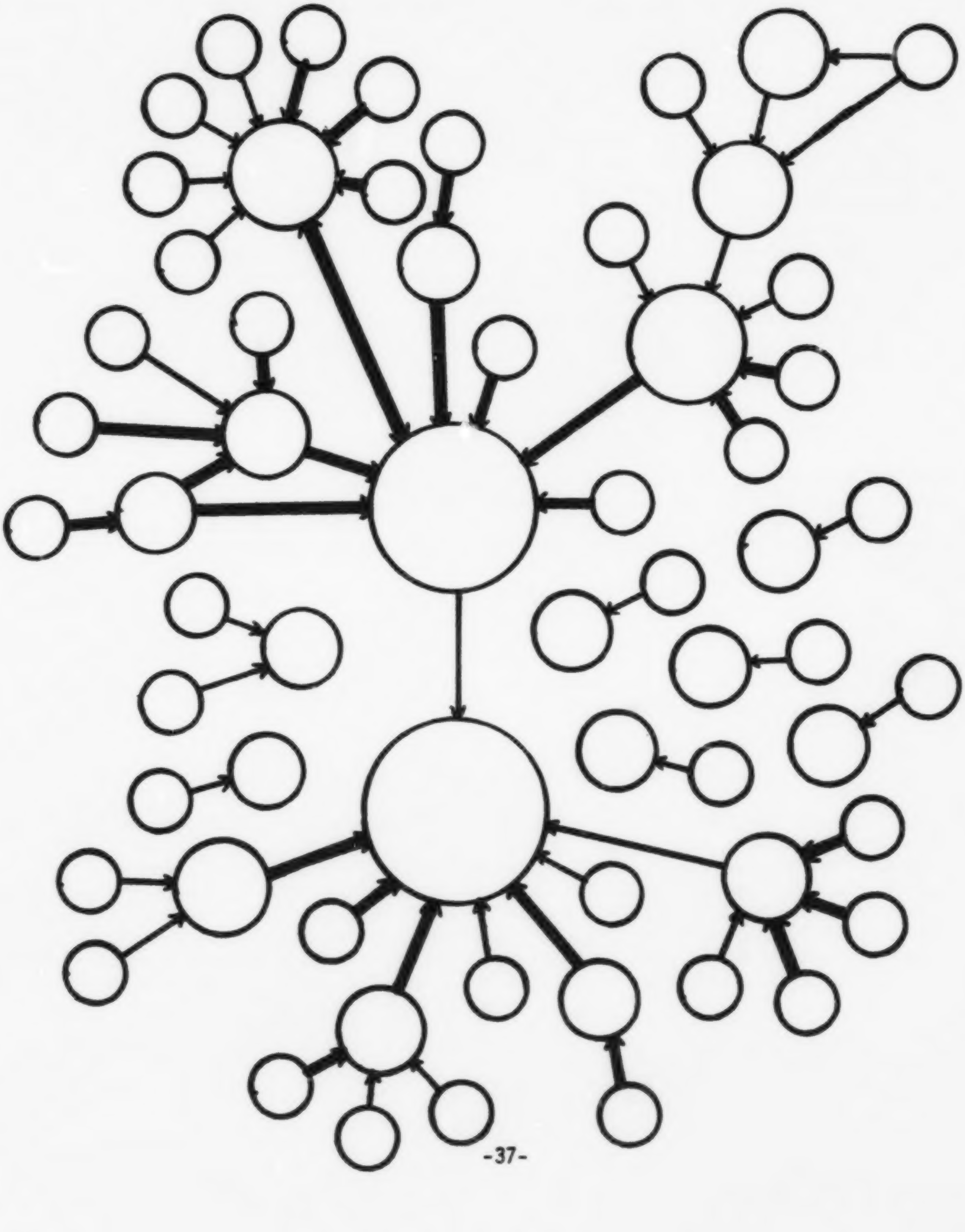
[1] These same questions were also presented to approximately ¼ of the Amish landowners. Their response, however, was different than the non-Amish. Non-Amish responded readily to the questions. The Amish, however, hesitated and most, even with intensive probing, would not provide a response. One of their beliefs is that pride should be avoided. Hence, asking an Amishman to select another as a "knowledgeable farmer" would tend to elevate one over the other. Besides, their livelihood is agricultural and "we are all supposed to be good farmers." Therefore, the Amish did not respond to the questions, although there is evidence suggesting advice is sought from parents and other relatives concerning agricultural operations on the farm.

Figure 1. Sociometric choice patterns of farmers: An illustration of opinion leadership among the non-Amish in the Black Creek.



he would like to see serve on such a board, if one were developed in their area. These board members would hold positions of importance in the area exerting influence within the community relative to decisions on pollution control. Furthermore, they would have contact with government as representatives of the area farmers. We assume that when farmers gave their three choices, they were looking for people they could trust, whose judgment they could respect and in whom they were willing to feel confident.

A comparison was made between the group of 8 farmers selected as opinion leaders and the group generated in the question concerning the pollution control board. Of the 8 farmers selected in either the "Opinion" or the "Advice" questions, 6 were also most often selected as members of the pollution control board. This further confirms our beliefs that the farmers selected as leaders in Figure 1 are, in fact, considered to be respected and influential in the community.

These eight opinion leaders also have characteristics which are different from the non-leaders in the watershed. Table 8 suggests marked differences in socio-economic characteristics. The opinion leaders are older, receive 94% of their income from farming (and are therefore committed to maintaining agriculture in their area), have incomes averaging $8,000 more than non-leaders, have almost three times the acreage and have more organizational affiliations than non-leaders by 5 to 1. The leaders thus have organizational networks that provide them with access to resources and other farmers throughout the area.

These leaders also have greater contact with agency people. They have twice the contact with local extension agents, SCS and SWCD personnel, four times the contact with county commissioners and twice as much interaction with personnel from the land grant university.

We believe that working through this small group of eight identified opinion leaders that we will ultimately have contact with the non-leaders. They cannot only teach each other about conservation problems, but eventually the two groups may work together in setting local pollution standards and controls. By following this procedure, we can gain access to the entire social structure of the non-Amish.

SOCIAL STRUCTURE IN THE AMISH COMMUNITY

We have learned that the Amish cannot be approached in the same way as the non-Amish. Rather than identifying several opinion leaders, we found that gaining approval and acceptance from the Bishop was an important component in establishing legitimation among the Amish. Several meetings were held with the Bishop to become acquainted and to elicit his support. Through the Bishop's influence, we were able to locate an Amish family that was willing to provide the interviewers with room and board during the interview phase of the project.

Table 8. Characteristics of Non-Amish Opinion Leaders and Non-leaders in the Black Creek*

Characteristic	Leaders	Non-Leaders
Mean Age	52 years	46 years
Education	Some High School	Some High School
% Income from Farming	94%	71%
Gross Family Income, 1973	$23,000 - 25,000	$15,000- 17,000
Number of Years in Farming	34	26
Number of Acres	294	108
Number of Organizations Belonged To	5	1
Percent Contact (during last year) with:		
Extension Agents	50%	22%
Agricultural Stabilization	100%	42%
Farmers Home Administration	0%	4%
Federal Crop Insurance	13%	13%
Allen Co. SWCD	88%	42%
Vocational Agricultural Dept.	63%	8%
County Commissioners	50%	11%
County Council Members	25%	6%
Dept. of Natural Resources	25%	6%
Purdue University	100%	42%

*Leaders were those (8) farmers named 3 or more times in response to the question "Who do you think is well-respected in this (watershed) for his general agricultural practices and abilities?" Non-leaders were all other non-Amish respondents.

Appointments with Amish farmers were made possible through the aid of an Amishman hired to arrange interviews. His work consisted of personally visiting the homes of each Amish landowner in the Black Creek to set a time and legitimate the presence of the interviewer. Without his help it is doubtful that any interviews would have been possible. Because the Amish have relatively little contact with outsiders they are often suspicious of them, regardless of the good intentions of the people. This factor can lead to complications in the interviewing process.

The elaborate process of living in an Amish home while conducting the interviews, hiring an Amishman to make appointments and personally being acquainted with the families proved worthwhile in the long run, as the response rate was very high. Only two Amishmen refused to be interviewed. But to obtain this success rate required persistence, personal involvement in the lives of the Amish and understanding of family relationships and ties in the watershed. This was obviously time-consuming, yet we believe the Amish feel we are interested in helping them solve their conservation problems rather than merely imposing our program on them.

Contrasting the approaches used to interview Amish and non-Amish suggests that it is important to know the composition of the population living within the watershed. It is important to know what religious or other constraints, if any, exist. It must be recognized that there is a social structure regardless of the type of community and that by properly approaching that structure, one can gain entry. But we have learned that the Amish and non-Amish must be approached differently if we hope to enjoy any degree of success.

SUMMARY

We have learned much from the past three years working with the Amish and non-Amish landowners. Most obvious is that they cannot be approached the same in conservation work. Non-Amish, because of their exposure to different agricultural practices, appear less doubtful of the conservation practices. Since their acreage is larger than the Amish, frequently a decision to sign a contract for work with the SWCD can be done by one landowner. The Amish, however, are more skeptical of the "new" practices and their ability to use them on their farms. Furthermore, because of small acreage (usually 80-100 acres) decisions to make grass waterways, etc. can often involve multiple farms. Arriving at a group decision can be most difficult, especially when family patterns and kinship ties may complicate the decision.

In spite of the fact that the Black Creek project has only entailed 12,000 acres and the Amish population is significant in only a few states. We believe that many of the procedures utilized in this project to gain access to local landowners could be followed in other projects. There is an obvious need for a socially-oriented person to spend full time interacting with landowners, gaining their confidence and giving them an opportunity to express their opinions and concerns as the project progresses.

This person can also provide useful information regarding the farmers' reactions to contractors which could help avoid situations that may permanently sever project-landowner relations.

Identifying leaders through survey methods should be useful to other studies. Working with a small group of landowners selected by peers can contribute greatly to the success of the project. These leaders can help in discussing alternative methods of controlling pollution and may offer suggestions on how to avoid the impression of force by legislation. They also are a mechanism of instigating instant local involvement to legitimize the progress of the project.

Finally, a personal approach to involving landowners in decisions is an important part in helping them gain confidence in project personnel. One of the two Amishmen that refused to be interviewed two years ago sought us out for advice and help on solving a water problem on his land, although we had to wait for a six-inch rain before he realized he had a problem. Yet, as a result of the contact he knew where to turn for help. In sum, both Amish and non-Amish can be reached if we are willing to be patient yet persistant, and plan our involvement with local people.

The success of the Black Creek project can be measured in many ways. The benefits from the social component will be difficult to quantify. However, we believe that a significant contribution to the overall success of the project can be attributed to the interplay between the sociological and the technological phases in the Black Creek.

TILLAGE AND SIMULATED RAINFALL STUDIES

by

J. V. Mannering, D. R. Griffith, and C. B. Johnson*

ABSTRACT

Conventional and conservation tillage systems for corn production were located on test plots chosen to represent the dominant soil capability subclasses within the 12,000 acre Black Creek Watershed. The objectives of the demonstration were to test tillage effects on soil and water management and crop yields. In addition, the equipment needs and recommended procedures to be followed by the operators were also evaluated. Results to date show fall chiseling produced corn yields equal to or greater than turn plowing on two of the three lake plain soils tested. The reduced yield on the chiseled plot at one location resulted from lower stand. Shallow tillage with a disk or field cultivator produced yields comparable with chiseling or plowing on two of the three lake plain soils and on both of the upland (glacial till) soils. Results from no till comparisons were highly variable, but usually no till was more competitive where drainage and weed control was better.

Simulated rainfall tests were conducted in 1973 and 1974 to develop information (base values) for the sediment contributions of the major soil capability units within the watershed and to determine the effects of various forms of tillage, residue management, and crop species on the overall erosion-sedimentation process. On the basis of gross erosion, results to date show the sloping soils of the uplands (glacial till) to be potentially more damaging than nearly level lake plain soils to water quality. Soil erosion rates were 3 or more times higher from these soils than from the nearly level lake plain soils. Within the nearly level lake plain soils, soil loss differences appeared to be closely related to soil texture and structure. Tillage system and the associated influence on crop residues were shown to have major effects on the soil erosion. In late spring tests soil losses from fall chiseling were approximately 1/2 to 3/4 those from fall turn plowing and soil losses from both shallow fall disking and no tillage were approximately 1/4 of those from fall turn plowing. The amount of residue remaining on the surface was inversely related to the amount of soil loss.

INTRODUCTION

The Black Creek Water Shed is an area of intensive farming with an estimated 60% of the area devoted to row crop (corn and soybean) culture in an average year. The dominant cultural practices used in corn and soybean production within the watershed consists of fall turn-plowing, secondary tillage for seedbed preparation in the spring and cultivation for weed control. Although this method of crop production is agronomically sound it does leave a large percent of the watershed unprotected and subject to erosion during a large part of the year. Conservation tillage systems have been shown to effectively reduce soil erosion at several locations in the Cornbelt (2, 3, 5, 6). If these practices are adaptable to soils within the Black Creek Watershed, they could have a significant influence in reducing both field erosion and the resultant sediment problem from row crop culture.

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The objectives of this study are, therefore, to:

1) demonstrate the suitability of various conservation tillage systems on the dominant soil capability subclasses in the watershed;
2) determine base soil loss values (under fallow conditions) of these dominant soils. More specifically to assess these major soils as to their relative erodibilities as a means of evaluating their potential for affecting water quality through the sedimentation process;
3) determine the erosion control effectiveness of several methods of conservation tillage in comparisons with conventional systems on these major soils.

PROCEDURE

Tillage Demonstration

Tillage demonstration sites using farmer-cooperators to perform all cultural practices were located in 1973 and tested in 1974 on three main groups of soils: (1) the rolling upland silty soils with clay subsoils (Morley, Blount, Pewamo); (2) the upper, nearly level, lake plain sandy, loamy and silty soils with clay loam subsoils or clays under deep loams (Oshtemo, Whitaker, Rensselaer and Haskins); and (3) the nearly level lake plain with silt loam, clay loam or clay surfaces and clay subsoils (St. Clair, Nappanee and Hoytville). Tillage systems compared included: (a) fall plow, (b) spring plow (both treatments (a) and (b) consist of turn plowing, secondary seedbed preparation by disking or field cultivation in the spring and planting), (c) fall chisel (chiseling in the fall followed by secondary seedbed preparation in the spring), (d) disking once or twice (light disking 3 - 4 inches deep--all disking operations performed in the spring before planting, if once, it was done in the spring before planting), (e) no-till (planting in a narrow tilled slit without any prior tillage). A more detailed description of these systems and the soil and crop conditions resulting from their use are reported elsewhere (1). Stand counts, plant height, and yields were recorded at each location. All tillage systems were not included at each test site because of either their lack of suitability to soil conditions or because of a lack of adequate equipment.

RESULTS

Tillage Demonstration

Rolling upland-glacial till soils: This area is characterized by sloping Morley, level Blount and depressed Pewamo soils developed from glacial till. The Morley soil is particularly subject to water erosion. A large part of the upland portion of the watershed is farmed by Amishmen using horse-drawn tools and two row planters. Four tillage systems (some especially adapted for this test) using horse-drawn equipment were compared on the Ben Eicher farm on both a Morley silt loam and a Blount silt loam soil. Results are reported in Table 1.

Table 1. Corn Stand, Height [1/] and Yield. Eicher Farm

	Morley Silt Loam 4-6% Slope			Blount Silt Loam 0-2% Slope		
Tillage treatment	Stand (1000)	Height (in)	Yield (bu/A)	Stand (1000)	Height (in)	Yield (bu/A)
Spring plow	10.6	10	31	12.5	13	49
Fall plow	11.2	12	34	11.4	10	44
Disk twice	13.0	13	35	11.5	13	40
No til	12.5	11	19	9.3	12	43

1/ Corn planted May 28, plant height recorded June 22.

Upper (loamy) lake plain soils: The pattern of soils along the outer, higher portion of the lake plain includes loamy sands, sandy loams, and loams with clay loams only in the depressed dark colored areas. Soil drainage is more rapid and soils warm faster than on the more clayey lower lake plain closer to the Maumee River. Based on other research (1) there should be a wide range of tillage systems adapted to this soil area. Two tillage trials were initiated on these loamy soils and results are reported in Tables 2 and 3.

Table 2. Corn Stand, Height[2/] and Yield. Ehle Farm

	Oshtemo Loamy Fine Sand			Whitaker Loam			Rensselaer Clay Loam		
Tillage treatment	Stand (1000)	Height (in)	Yield (bu/A)	Stand (1000)	Height (in)	Yield (bu/A)	Stand (1000)	Height (in)	Yield (bu/A)
Spring plow	43.2	29	21	31.8	24	72	25.8	29	168
Fall plow	34.0	27	64	34.0	25	80	28.8	30	118
Fall chisel	31.8	30	54	31.2	26	111	29.0	32	184
Disk once spring	29.8	29	38	24.6	24	84	28.2	30	176
Disk twice spring	33.0	31	30	29.0	22	94	26.4	30	187
No-til	34.0	27	27	30.0	23	81	28.6	24	128

1/Corn planted May 2, plant height recorded June 21.

Table 3. Corn Stand, Height[1] and Yield. Yerks Farm

	Whitaker Loam			Rensselaer Clay Loam		
Tillage treatment	Stand (1000)	Height (in)	Yield (bu/A)	Stand (1000)	Height (in)	Yield (bu/A)
Spring plow	23.6	14	91	24.4	—	80
Fall plow	23.6	14	84	23.2	—	81
Fall chisel	24.6	13	101	24.2	—	77
Disk twice spring	23.6	15	.04	23.0	—	82

1/Corn planted May 27, plant height recorded June 21.

Lower (clayey)lake plain soils: This is the smoothest part of the lake plain with slow surface drainage and a nearly level light colored swell and dark colored swale landscape. The principal light colored soils are poorly drained Nappanee silt loam and silty clay loam and the principal dark soils are poorly drained Hoytville silty clay loam and clay. Results of the tillage trial are reported in Table 4.

Table 4. Corn Stand, Height[1] and Yield. Lake Farm

	Nappanee Silt Loam			Hoytville Silty Clay Loam		
Tillage treatment	Stand (1000)	Height (in)	Yield (bu/A)	Stand (1000)	Height (in)	Yield2/ (bu/A)
Spring plow	8.0	9	53	16.6	19	—
Fall Plow	20.2	20	73	16.2	17	—
Fall chisel	19.6	14	57	16.4	18	—
Disk fall and spring	17.0	16	48	15.8	14	—
Disk twice spring	15.4	14	35	17.2	16	—
Field cultivate spring	17.4	12	42	14.6	12	—

1/Corn planted May 6, plant height recorded June 21.

2/Plots too variable to record yield.

DISCUSSION

Tillage Demonstration

The 1974 growing season was unusual throughout with excess rain in the spring, a severe summer drought and an early September frost. Much lower than normal yields resulted in the demonstrations. Plant stress from conditions such as these tend to amplify differences in plant growth and yield caused by minor soil variations. For this reason yield information reported in this paper may inadequately characterize corn response to the different tillage methods on some of the soils.

However, there were some observations made during the year that are useful. For example, on the Eicher Farm during a heavy shower on June 22, water was observed to run off quickly from spring and fall plowed plots on 4-6% slopes and this runoff contained visable silt. On disked plots and no til plots runoff was less and also was practically clear.

Although the results are somewhat variable, fall chiseling when included in the test produced corn yields equal to or better than plowing on all but one location. Chiseling is on the increase in the area and would appear to offer all but Amish farmers an effective soil conserving system adapted for widespread use in basic land preparation.

Shallow tillage with a disk or field cultivator produced yields comparable with chiseling or plowing on Rensselaer, Whitaker, Morley, and Blount soils, but yields were reduced on Nappanee.

On the two farms where no til was included, yields were acceptable on Blount and Whitaker soils, but were reduced on Morley, because of poor weed control, and on Rensselaer, where growth was delayed due to cool weather. On Oshtemo loamy fine sand, variation within the trial was great, but no-til had no apparent yield advantage in a droughty situation where the presence of surface residue should have increased soil moisture and therefore yield.

PROCEDURE

Erosion Studies Under Simulated Rainfall

Simulated rain tests were conducted in 1973 at 4 locations to determine the base values for the sediment contributions of the major capability units in the study area. These same locations were used in 1974 to test the influence of tillage system and residue management on soil erosion. These 4 locations consisted of 4 distinct soil types which are representative of over 80% of the major soil capability units contained in the Black Creek Watershed. The four test sites are identified in Table 5.

Table 5. Identification of Test Locations[1/]

Location	Soil Type	% Slope[2/]	Prior Crop[3/]
1. Yerks Farm	Haskins loam	0.15-1.76	Corn
2. Hirsch Farm	Nappanee clay loam	0.72-0.66	Corn
3. Hirsch Farm	Hoytville silty clay	0.53-0.75	Corn
4. Bennett Farm	Morley clay loam	5.08-3.99	Soybeans

[1/] Locations had to be moved a short distance in the 1974 tests to avoid confounding effects of 1973 tests on 1974 results.

[2/] The percent slope given first is for the 1973 tests, the second value is for 1974 tests.

[3/] The crop preceeding the fallow plot tests was corn in 3 of the locations and soybeans on the 4th location. Also, the residues tested in the 1974 tillage study were also corn in 3 of the tests and soybeans in the 4th.

The plot preparation for the 1973 tests consisted of turn plowing in the early spring and two diskings immediately prior to the application of the test storms. The final disking was performed parallel to the dominant slopes. Prior crop residues were not removed prior to turn plowing. In the 1974 tests the following treatments were applied in the fall of 1973:

1) Check--No tillage performed after harvest of crops. All residues left on the surface.
2) Disk--Light disking (2-3 inches deep)--slight incorporation of residues.
3) Chisel--Chiseling (6-8 inches deep)--some incorporation of residues.
4) Plow--Plow (6-8 inches deep) nearly all residues buried. No further treatment was applied prior to applying simulated rain tests in the late spring of 1974. These tillage treatments represented conditions that would occur in late winter and early spring after the soil had undergone the winter weathering processes and based on prior research should be the most critical erosion period for most if not all treatments compared. All treatments in both the '73 and '74 tests were replicated once. Individual plots were 12 feet by 35 feet. A randomized block design was used where applicable.

Simulated rainfall tests in both '73 and '74 consisted of the following:

Initial storm--60 minutes of rainfall at 2-1/2 inches per hour.
Wet storm--30 minutes of rainfall at 2-1/2 inches per hour applied twenty-four hours following the initial storm.
Very wet storm--30 minutes of rainfall at 2-1/2 inches per hour applied fifteen minutes after the end of the wet storm.

Samples were taken for antecedent soil moisture determinations prior to the initial and wet tests. In the 1974 tests surface residue cover was determined photographically on each plot. Runoff rates and amounts were determined by the use of flumes and water stage recorders and 1% aliquot samples of runoff were taken throughout the test for determining sediment load and composition. Procedures developed in earlier studies (4) for conducting simulated rain tests and analyzing the results were used in this study.

RESULTS

Simulated Rainfall Tests

1973 results from the initial, wet, very wet, and 3-storm totals are given in table 6. Included is information on runoff, infiltration, soil concentration, and soil loss from the 12' x 35' plots on all 4 locations.

Table 6. Summary of Results from Fallow Plots (12' x 25') by test storms. July-August 1973

Soil Type	Storm	Appl. in	Infil. in	Runoff in	Soil Cont. Runoff %	Soil Loss T/A
Haskins L.	Initial (60 min)	2.50	1.24	1.26	1.41	2.03
Nappanee C.L.	"	"	1.77	0.73	0.90	0.78
Hoytville Si.C.	"	"	1.63	0.87	0.94	0.96
Morley C.L.	"	"	1.08	1.43	3.91	6.55
Haskins L.	Wet (30 min)	1.25	0.29	0.96	1.17	1.25
Nappanee C.L.	"	"	0.41	0.85	0.62	0.61
Hoytville Si.C.	"	"	0.22	1.03	0.76	0.88
Morley C.L.	"	"	0.18	1.07	3.43	4.23
Haskins L.	Very Wet (30 min)	1.25	0.07	1.18	0.94	1.25
Nappanee C.L.	"	"	0.20	1.05	0.54	0.61
Hoytville Si.C.	"	"	0.10	1.15	0.86	1.01
Morley C.L.	"	"	0.11	1.14	3.46	4.60
Haskins L.	Total (2 hrs)	5.00	1.60	3.40	1.23	4.53
Nappanee C.L.	"	"	2.37	2.63	0.72	2.04
Hoytville Si.C.	"	"	1.96	3.04	0.87	2.85
Morley C.L.	"	"	1.37	3.64	3.92	15.38

1/Results are averages of two replications.

2/Runoff and soil loss have been adjusted to a constant intensity of 2-1/2 in/hr.

3/Soil content of runoff is lbs. actual soil loss/lbs. actual runoff x 100. Values presented for totals are obtained by adjusted soil loss/adjusted runoff, therefore do not fully agree with unadjusted values for the individual storms.

The 1974 tests on the effects of tillage system on soil and water management are presented in Tables 8-12. Table 7 gives the photographically determined estimates of crop residue cover as affected by tillage system on all 4 test locations.

Table 7. Percent surface cover as influenced by tillage system.1/

	Treatment			
Soil Type	Check	Disk	Chisel	Plow
Haskins L.	57	55	36	1
Nappanee C.L.	53	58	29	5
Hoytville Si.C.	78	77	57	4
Morley C.L. 2/	26	17	12	1

1/Cover estimates are averages of 6 determinations.

2/The Morley soil had soybean residues--the other 3 locations had corn residues.

Table 8. Summary of tillage results 1/ by test storms. May-June 1974. Location--Haskins Loam

Treatment	Storm	Appl.	Infil.	Runoff 2/	Soil Cont. Runoff3/	Soil Loss2/
		in	in	in	%	T/A
Check	Initial (60 min)	2.50	1.52	0.98	1.40	1.43
Disk	"	"	1.22	1.28	0.83	1.09
Chisel	"	"	1.22	1.28	1.81	2.58
Plow	"	"	0.77	1.73	2.74	5.47
Check	Wet (30 min)	1.25	0.67	0.58	0.64	0.42
Disk	"	"	0.46	0.79	0.36	0.32
Chisel	"	"	0.28	0.97	1.65	1.79
Plow	"	"	0.25	1.00	2.67	3.04
Check	Very Wet (30 min)	1.25	0.43	0.82	0.54	0.50
Disk	"	"	0.14	1.11	0.27	0.34
Chisel	"	"	0.15	1.10	1.46	1.78
Plow	"	"	0.16	1.09	2.51	3.13
Check	Total (2 hrs)	5.00	2.62	2.38	0.87	2.35
Disk	"	"	1.82	3.18	0.49	1.75
Chisel	"	"	1.65	3.35	1.62	6.15
Plow	"	"	1.18	3.82	2.69	11.64

1/Results are averages of two replications.

2/Runoff and soil loss have been adjusted to a constant intensity of 2-1/2 in/hr.

3/Soil Content of runoff is lbs. actual soil loss/lbs actual runoff x 100.

Table 9. Summary of tillage results1/ by test storms. May-June 1974.
Location Nappanee clay loam.

Treatment	Storm	Appl.	Infil.	Runoff 2/	Soil Cont. Runoff3/	Soil Loss2/
		in	in	in	%	T/A
Check	Initial (60 min)	2.50	1.26	1.24	0.28	0.40
Disk	"	"	1.32	1.18	0.20	0.32
Chisel	"	"	1.33	1.17	0.75	0.99
Plow	"	"	1.38	1.12	1.47	1.85
Check	Wet (30 min)	1.25	0.58	0.67	0.21	0.16
Disk	"	"	0.83	0.42	0.15	0.07
Chisel	"	"	0.54	0.71	0.62	0.48
Plow	"	"	0.58	0.67	1.00	0.77
Check	Very Wet (30 min)	1.25	0.44	0.81	0.18	0.17
Disk	"	"	0.52	0.73	0.11	0.09
Chisel	"	"	0.31	0.94	0.63	0.63
Plow	"	"	0.31	0.94	0.92	0.96
Check	Total (2 hrs)	5.00	2.28	2.72	0.23	0.73
Disk	"	"	2.67	2.33	0.18	0.48
Chisel	"	"	2.18	2.82	0.66	2.10
Plow	"	"	2.27	2.73	1.16	3.58

1/Results are averages of two replications.

2/Runoff and soil loss have been adjusted to a constant intensity of 2-1/2 in/hr.

3/Soil content of runoff is lbs actual soil loss/lbs actual runoff x 100.

Table 10. Summary of tillage results1/ by test storms. May-June 1974. Location Hoytville silty clay.

Treatment	Storm	Appl. 2/	Infil.	Runoff	Soil cont. Runoff3/	Soil Loss2/
		in	in	in	%	T/A
Check	Initial (60 min)	2.50	1.33	1.17	0.18	0.24
Disk	"	"	1.74	0.76	0.20	0.17
Chisel	" "	"	2.01	0.49	0.49	0.27
Disk	"	"	1.32	1.18	0.67	0.90
Check	Wet (30 min)	1.25	0.68	0.57	0.17	0.11
Disk	"	"	0.82	0.43	0.29	0.14
Chisel	"	"	1.00	0.25	0.50	0.12
Plow	"	"	0.48	0.77	0.56	0.48
Check	Very Wet (30 min)	1.25	0.40	0.85	0.14	0.14
Disk	"	"	0.31	0.94	0.11	0.11
Chisel	"	"	0.54	0.71	0.48	0.35
Plow	"	"	0.37	0.88	0.55	0.54
Check	Total (2 hrs)	5.00	2.41	2.59	0.17	0.49
Disk	"	"	2.87	2.13	0.17	0.42
Chisel	"	"	3.55	1.45	0.45	0.74
Plow	"	"	2.17	2.83	0.60	1.92

1/Results are averages of two replications.

2/Runoff and soil loss have been adjusted to a constant intensity of 2-1/2 in/hr.

3/Soil content of runoff is lbs actual soil loss/lbs actual runoff x 100.

Table 11. Summary of tillage results1/ by test storms. May-June 1974. Location Morley clay loam.

Treatment	Storm	Appl.	Infil.	Runoff 2/	Soil Cont. Runoff3/	Soil Loss2/
		in	in	in	%	T/A
Check	Initial (60 min)	2.50	0.57	1.93	1.21	2.65
Disk	"	"	0.75	1.75	1.51	2.96
Chisel	"	"	0.75	1.75	3.61	7.08
Plow	"	"	0.59	1.91	4.57	9.81
Check	Wet (30 min)	1.25	0.21	1.04	1.25	1.50
Disk	"	"	0.34	0.91	1.21	1.27
Chisel	"	"	0.27	0.98	3.24	3.54
Plow	"	"	0.20	1.05	3.91	4.60
Check	Very Wet (30 min)	1.25	0.04	1.21	1.36	1.82
Disk	"	"	0.16	1.09	1.08	1.32
Chisel	"	"	0.16	1.09	2.36	2.89
Plow	"	"	0.25	1.00	3.48	3.85
Check	Total (2 hrs)	5.00	0.82	4.18	1.26	5.97
Disk	"	"	1.25	3.75	1.31	5.55
Chisel	"	"	1.18	3.82	3.12	13.51
Plow	"	"	1.04	3.96	4.07	18.26

1/Results are averages of two replications.

2/Runoff and soil loss have been adjusted to a constant intensity of 2-1/2 in/hr.

3/Soil content of runoff is lbs actual soil loss/lbs actual runoff x 100.

Table 12. Summary of soil loss results as affected by tillage system from 5 inches of simulated rainfall on 4 locations.

Location	Treatment (Loss in T/A)			
	Check	Disk	Chisel	Plow
Haskins L.	2.44	1.8	6.2	11.6
Nappanee C. L.	0.7	0.5	2.1	3.6
Hoytville SiC.	0.5	0.4	0.7	1.9
Morley C. L.	6.0	5.6	13.5	18.3

DISCUSSION

Simulated Rainfall Tests--Fallow Plot Study

Table 6 shows major soil capability units within the water shed to erode at varying rates. The major effect can be attributed to slope difference as evidenced by soil losses of over 15 T/A on the 5% Morley soil in the glacial-till portion of the watershed compared to soil losses of less than 5 T/A on the more level (lake plain) portion of the watershed (Haskins, Nappanee, Hoytville) when exposed to 5 inches of intense rainfall. However, even on nearly level slopes significant soil loss differences occurred. Notice that even though the Haskins soil had the least slope, soil loss values were essentially twice those on the Hoytville and Nappanee soils. Laboratory measurements show both the Nappanee and Hoytville soils to have better structure than the Haskins. Both the Nappanee and Hoytville soils developed major shrinkage cracks which greatly increased infiltration as compared to the Haskins and Morley soils (Note infiltration data). This was also a major factor in reducing soil loss.

Soil losses were generally quite low on the nearly level soils as could be expected. This would indicate that the major soil erosion problem in the watershed does not occur on these lake plain soils, but rather on the sloping-glacial till soils in the north part of the watershed. However, the transportability of the sediment (the amount that gets into the Maumee River) and in turn its influence on nutrient transport from the different soils within the watershed will be better evaluated by physical and chemical analyses still underway.

DISCUSSION

Simulated Rainfall Tests--Tillage Study

Appreciable soil losses occurred on the Haskins loam (Table 8) from both the fall chisel and fall plowed treatments. Both infiltration differences and soil concentrations of the runoff were important factors in the results obtained. The appreciably larger infiltration on the check plot compared to the other 3 treatments is difficult to explain and may result from minor topography differences between plots rather than a result of treatment. In the comparison between infiltration amounts between fall chisel and fall plow the advantage of the chisel system could well be that the rougher surface created more surface storage, thus reducing runoff amounts particularly during the initial run. The major effects of treatment appear to show up in soil content of runoff and be closely tied to surface protected by last season's corn residues. In table 7 you will find that both the check and disk treatments had over 50% of the surface covered, compared to slightly over 1/3 for the chisel treatment and only 1% for the plowed treatment.

Table 9 gives the same results for the Nappanee soil. Here you find little difference in infiltration resulting from treatments. However, the past season's corn residues have significant effects on soil concentration of the runoff and therefore soil loss. Surface cover amounting to 53, 58, 29, and 5% from the respective treatments of check, disk, chisel and plow resulted in soil losses of 0.7, 0.5, 2.1 and 3.6 tons/acre.

On the Hoytville soil (Table 10) infiltration amounts were highly variable again illustrating the major effects of topographic variability between plots on runoff amounts on the nearly level areas. However, there did appear to be some advantage of the chisel treatment in storing surface water. The major effects of treatment were again tied closely to residue cover. Corn residues covered 78, 77, 57 and 4% of the soil surface, respectively, on the check, disk, chisel and plowed plots. Resultant soil losses were 0.5, 0.4, 0.7 and 1.9 tons/acre, respectively.

Two factors predominate on the Morley soil (Table 11). First and most significant is the percent slope of almost 4% compared to less than 2% on all other locations. Note the increased amount of runoff compared to the other 3 locations. The second factor is that these tests were made on soybean land where much less residue was present than on corn land. Table 7 shows surface protection to be 26, 17, 12 and 1%, respectively, for the check, disk, chisel and plow treatment (compare these values with those on corn land). These residues, although less than for corn land, were still a factor in reducing soil content of the runoff. Compare, particularly, the differences in soil content and soil loss between the check and disk treatment versus the chisel and plow treatments.

Table 12 shows major differences in soil loss to occur between locations. The effect of slope on total erosion remains a dominant factor. A soil loss of greater than 18 tons/acre occurred on the plowed Morley soil with a 4% slope, 11.6 tons/acre occurred on the plowed Haskins soil (1.7% slope) and less than 4 tons per acre occurred on plowed slopes of less than 1%. A comparison of the two nearly level locations (Hoytville and Nappanee) shows the better structured soil to have positive effects both in increasing infiltration and reducing soil detachment. Note particularly the plowed treatments where erosion from 5 inches of rain resulted in losses of 1.9 tons/acre from the Hoytville compared to 3.6 tons/acre from the Nappanee.

CONCLUSIONS

These results are of a preliminary nature and further analyses might alter them slightly. However, it can be definitely concluded that: (1) Type of tillage performed in the fall can have major effects on soil losses during the winter and spring months. Tests in late spring and early summer showed soil losses from fall chiseled land to be 53, 58, 37 and 74%, respectively, of those from fall plowed land on the Haskins, Nappanee, Hoytville and Morley soils. And further that soil losses from either the check or light disk treatment to be 18, 17, 24 and 32%, respectively, of those from fall plowing on these same soils. All of the treatments but the disk treatment were probably more effective in reducing soil loss earlier in the season prior to weathering and loss of surface roughness and/or loss of some of the residue from the surface. Past research has shown fall soil losses to be greater (as much as two times) from disking than from the check (no treatment). However, at this stage of the season fall disking appeared to be every bit as effective as the check in controlling soil losses.

(2) Type of residue affects erosion. These tests indicate that the amount of residues remaining on the surface following corn is much greater than following soybeans in late spring. Soybean land also appears to be more easily detached and transported by the runoff.

(3) The tillage demonstrations performed to date indicate fall chiseling to be a viable alternative to fall turn-plowing on most soils in the watershed based on the corn yields obtained. Additional research and testing is needed before confident recommendations can be made regarding the suitability of shallow tillage and no til on many of the soils in the watershed.

(4) Although significant soil loss reductions can be attributed to conservation tillage systems in the nearly level (lake plain) portions of the watershed, it should be emphasized that soil losses from these areas are comparatively small (even on fall plowed land). If further tests show that the soil loss from these areas do not contribute a disproportionate share of the Maumee Basin sediment problem, perhaps these systems should not be recommended in areas where they can not be competitive agronomically or economically.

(5) Gross field erosion is 3 or more times as great from the sloping lake plain soils as the nearly level lake plain soils (under bare conditions). This would indicate that conservation measures should be first concentrated in the sloping portions of the watershed.

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USES OF PESTICIDES AND FERTILIZERS IN THE BLACK CREEK WATERSHED

by

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ABSTRACT

Analyses of a questionnaire made among Black Creek landowners of farms over 10 acres is presented in a series of 12 tables with contrasts between responses from 57 non-Amish and 32 Amish owners. Amish own or partly own 96 percent of their land vs. 69 percent for non-Amish. A complete land use summary covers all but 540 acres and indicates high crop and hay acreage and low pasture and woodlands. Use of herbicides is common but more so among non-Amish while insecticide use is uncommon.

Manures are highly depended on for pasture, and, manures plus fertilizers for corn and hay for nearly a half of Amish growers. Chemical fertilizers are used by non-Amish with two or three used on corn and low amounts used on soybeans. Wheat and oats are fertilized with mixed grades of fertilizer by both non-Amish and Amish. Application time for fertilizers is 70 percent before planting for non-Amish and 32 percent for Amish who use most at planting time.

Non-Amish use over twice the amount of N as Amish and a quarter more P and K for corn, the major crop. Hay and pastures are fertilized well by Amish, little or none by non-Amish.

Analyses of total N, P and K applied in sub watersheds reveals that there are no striking differences between them. A listing of fertilizers used by crops reveals a wide number of 1-1-1 and 1-4-4 grades and a tendency for non-Amish to use two or three fertilizers as plowdown and in the row while Amish tend to use one,mainly a mixed grade,at planting.

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USES OF PESTICIDES AND FERTILIZERS IN THE BLACK CREEK WATERSHED

Data reported here result from analyzing answers to a questionnaire administered to 80 landowners who were actively farming lands of 10 acres or greater area. Thirty-two respondents were Amish and 57 non-Amish. Because of differences in use of technologies in modern farming the two groups were analyzed and reported separately for this study.

The 89 respondents represent all but four 10 acre or larger landowners - 2 Amish and 2 non-Amish refused to cooperate. There were also 86 owners in the watershed of parcels less than 10 acres in size who were not interviewed. Many of these live in Harlan and along roads near Harlan.

Land tenure in Black Creek watershed as revealed by the 89 respondents is given in Table 1.

Table 1. Acres by Land Tenure in Black Creek Watershed. 1973

Class of Tenure	Non-Amish		Amish		Total Acres	Pct by Tenure
	Acres	Pct	Acres	Pct		
Fully owned	4923	55	2928	88	7851	65
Part owned	1249	14	257	8	1506	12
Rented from someone	2609[1]	30	126[2]	4	2735	23
Used from other sources	50	1	15	<1	65	<1
	8831	100	3326	100	12,157[3]	100

[1] 660 A reported as rented out to others. Probably is part of 2609A rented from someone.

[2] 128 A reported as rented out to others. Probably is same as 126 A rented from someone.

[3] Exceeds watershed acreage by 119 A.

The Amish own in full or in part 96 percent of the land they farm. Rental is probably from another Amish farm. Non-Amish own or partly own 69 percent and rent about 30 percent. This is in line with modern farms to have a base in owned land and to rent land in the neighborhood to enlarge in order to increase efficiency of machinery use.

In part I question 2 asked what use each acre of land was put to for that farmed personally by the owner-interviewee. Table 2 summarizes the land uses reported.

Table 2. Land use summary in watershed by 5 classes: for non-Amish and Amish. 1973

Growers	1 Croplands (Grain & hay)	2 Pasture	ST Col. 1 + 2 Grain, hay & pasture	3 Wood land	4 Wildlife and Recreation	5 Other (Bldgs., roads, lanes, etc.)	6 Totals
Non-Amish	7119	376	7495	398	110	313	8316
Amish	2282	457	2739	275	0	168	3182
	9401	833	10,234	673	110	481	11,498 [1]

[1] Accounts for all but 540 of the 12,038 acres in watershed. Four farmers did not cooperate in interview and some 86 owners of less than 10 acres of land were not interviewed.

Part I, qu.4 asked for acreages, yields and amounts of various fertilizers applied for major grain crops and hay. An "other" category (pasture, etc.) was also listed but was not thoroughly understood by interviewees. In Table 3 a summary of acreages by crops, hay and "other" is presented on a non-Amish and Amish basis.

Table 3. Acres by crops & pasture, non-Amish and Amish and comparison of land use by watershed including Columns 3, 4, 5 from Table 2, 1973.

Growers	1 Corn Grain	2 Corn Silage	3 Soybeans	4 Oats	5 Wheat	6 Hay	7 Other (pasture, etc.)	ST Col. 1-7 Grain, hay & pasture	From Table 1 Woods & wildlife	From Table 1 Other (Bldg. areas, roads, etc.)	8 Totals
Non-Amish	2749	100	3088	393	495	60	372[1]	7252	821	313	8386
Amish	565	140	0	467	149	628	679[2]	2628	443	168	3239
								9880			11,625

[1] Includes govt. program land on at least 5 farms.

[2] Probably includes pasture plus building areas, roads, and lanes of Table 2.

In comparing Tables 2 and 3 the subtotals and totals do not agree. (Grain hay and pasture 10,234 on ST Table 2 vs. 9880 on ST Table 3; Total acres, 11,498, col. 6, Table 2 vs. 11,625, col. 8, Table 3). This indicates a problem in understanding the various categories in the two questions and arriving at the same total land use by adding areas of the various crops and pasture.

USE OF PESTICIDES

Pesticide usage was not asked in the questionaire until 16 of the Amish had already been interviewed and data tables are incomplete to this extent. Table 4 lists numbers of growers who used pesticides on corn or soybeans in 1973.

Table 4. Use of pesticides on corn and/or soybeans. 1973

Growers	Number Using	Not Using	No Response	Not Asked
Non-Amish	42	13	2	--
Amish	9	7	-	16

47 of 57 non-Amish reported use while 9 of 16 Amish did so. From general knowledge of Amish operations, it is likely that at least half do use some pesticides.

Herbicides

In Table 5 the numbers using various corn and soybean herbicides are listed.

Table 5. Numbers of corn and soybean growers by type of herbicide used.[1]

Growers	Corn									
	Aatrex	Aatrex + Bladex	Aatrex + Lasso	Lasso + Banvel	Ramrod	Ramrod + 2.4.D	2,4,D	Atrazine + Princep	Not Used	No Resp.
Non-Amish 40	6	1	5	3	1	2	7	0	13	2
Amish 30	1	0	0	0	0	0	4	1	1	23[2]

Growers	Soybeans					
Non-Amish	Preforan	Amiben	Amiben + Lasso	Lasso	Not Used	No Resp.
53	2	36	1	1	11	2

[1] Amish do not grow soybeans.

[2] 16 Amish not asked about herbicides included in No. Resp. group.

Since Amish do not grow soybeans, that part of the question was not relevant.

For corn Aatrex and combinations of Aatrex are most popular with non-Amish with 2,4,D and 2,4,D mixtures the next most used. Amish preferred 2,4,D and Aatrex mixtures.

For soybeans Amiben is most popular and is used by two-thirds of the 53 growers. Less than one-fourth used no herbicides on soybeans.

The numbers of growers using various amounts of herbicides on corn and soybeans in 1973 are reported in Table 6.

Table 6. Numbers of corn and soybean growers by amount of herbicide used. 1973

	Corn														
	Qts. Herbicide/A														
	1	2	3	4	5	7	8	9	10	11	13	16	20	Not Used	No Resp.
Non-Amish 40	8	3	1	1	0	0	1	1	8	1	0	0	1	11	4
Amish 30	3	1	0	1	1	0	0	0	0	0	0	0	0	2	22[1/]
	Soybeans[2/]														
	Qts. Herbicide/A														
	1	2	3	4	5	7	8	9	10	11	13	16	20	Not Used	No Resp.
Non-Amish 53	3	1	1	1	11	4	1	7	0	8	1	1	1	11	2

1/ 16 of remaining 22 were not asked about herbicide.

2/ Amish do not grow soybeans.

19 of 31 using herbicides on corn use 5 or less quarts per acre and this included all the Amish. Only 12 used over 5 quarts.

Of 53 soybean growers 17 use 5 quarts or less and 23 use from 5 to 20 indicating the normal problems in combatting weeds in soybeans.

High application rates in Table 6 probably indicate two or more herbicides used at separate times such as a preemerge form followed later by 2,4,D. See paragraph under suggestions on last page.

Insecticides

Apparently very few corn growers use insecticides and those that do, use from 1 to 6 quarts per acre as reported in Table 7.

Table 7. Number of corn growers by type and amount of insecticide used. 1973

	40 Non-Amish	30 Amish	Rate of Application Non-Amish only Qt. Insecticide/A	No.
None used	32	9	—	—
Aldrin	5	0	1	3
Diazinon	1	0	5	2
No response	2	0	6	1
Does not apply to situation	11[1]	23[2]		

[1] Probably includes 11 of the 17 who did not grow corn in 1973. Six of the 32 on the none used line would also be in this group.

[2] 16 of the Amish were not asked this question.

Summary of Pesticide Usage

Black Creek watershed farmers seem to make only moderate usage of chemicals against weeds and soil insects. If used carefully by this proportion of growers there is no reason to expect adverse affects on water quality.

USE OF FERTILIZERS

Amish farmers practice general farming and usually keep some milk cows and a number of horses. They practice a general rotation of 2 years corn, oats for feed, and meadow 2 or more years. Some grow wheat as a cash grain crop and nearly every farm has some pasture.

Their farms are on sloping, erosive, only moderately dark colored upland soils often low in phosphate and potash. Rotations are needed as much to control soil tilth and erosion as to supply the forages they need as livestock feed.

The non-Amish occupy the eastern part of the upland and most of the level lake plain and generally follow cash grain and seed production. There is a considerable proportion of dark colored land with higher content of phosphate than found in the light colored lake beds and uplands.

Potash levels have generally been raised by fertilizing in the past 10-20 years. Growers recognize that adequate potash levels are needed for good production of corn, soybeans and hay. Needs for phosphorus are higher for wheat while oats seem to need the two in balance.

Fertilizer programs are designed to fit needs of individual farms and cropping systems followed. All crops respond fully to nitrogen and response to phosphate and potash varies with the soil supplies. In a series of tables which follow various aspects of fertilizing practices are considered as revealed from answers given by 89 respondents to the questionaire.

Crops and Fertilizing Practices

In Table 8 the number of non-Amish and Amish farmers growing each crop and their general fertilizer practices are listed. Note that the Amish grow no soybeans since these do not fit their needs for livestock or horse feed and they have not tooled up to handle a bean crop.

Table 8. Numbers of growers, acres of crops, and fertilizers used by 57 non-Amish and 32 Amish farmers. 1973

Crop	Growers	Acres Grown	Manure only	Manure + Fert.	One fertilizer only	Two or more fertilizers	None used	Pct. using fertilizer or manure
			numbers of growers					
Corn Grain	Non-Amish 40	2749	0	3	16	20	1	97
	Amish 30	565	0	11	19	0	0	100
Corn Silage	Non-Amish 1	100	0	1	0	0	0	100
	Amish 16	140	0	1	15	0	0	100
Soybeans	Non-Amish 53	3088	0	0	34	1	18	66
	Amish 0	0	0	0	0	0	0	0
Oats	Non-Amish 21	393	0	0	19	1	1	95
	Amish 28	467	0	0	28	0	0	100
Wheat	Non-Amish 25	495	0	0	12	11	2	92
	Amish 13	149	0	1	12	0	0	100

Table 8 continued.

Crop	Growers	Acres	Manure only	Manure + Fert.	One fertilizer only	Two or more fertilizers	None used	% using fertilizer or manure
			. . . . numbers of growers					
Hay	Non-Amish 8	60	0	0	3	0	5	37
	Amish 30	628	6	5	5	0	14	53
Pasture	Non-Amish 12	372	0	0	0	0	12[1/]	0
	Amish 28[2/]	679	17	2	2	0	7	75
Total Acres:		9,880						

1/ Includes at least 144 A of land on five farms in government programs.

2/ Four small farms without pasture; total only 145 acres.

The percent of farmers using manures and/or fertilizers is very high for corn, oats and wheat. Only two-thirds of non-Amish fertilize soybeans directly. Hay is fertilized by half the Amish and pasture by three-quarters in contrast to near neglect on the part of non-Amish. This reflects the high need by Amish for hay and forage and the low need by non-Amish who keep only a few cattle.

Pastures are favored areas for manure application due to easy access throughout the season. The practice of spreading on pasture probably encourages large losses of nitrogen by volatilization and consequent loss of nitrogen from which the grass could benefit.

In Table 9 the percentage of growers applying fertilizers on row of grain crop lands at different seasons is shown.

Table 9. Percent of farmers applying fertilizers on croplands by season. 1973

	Fall	Spring	Before Planting	At Planting	After Planting	Not Stated
Non-Amish	40	25	4	21	3	7
Amish	10	22	0	53	9	6

Since there is such a strong reliance on use of chemical fertilizers for corn, soybeans and small grains these figures probably apply mostly to these crops. Note that two-thirds of the non-Amish report bulkspreading fertilizers in fall or spring before plowing or just before planting, a quarter report use at planting, and only 3 percent after planting. The 21 percent who list application at planting may have used only row fertilizer in 1973.

Only a third of the Amish apply fertilizer ahead of planting and over one-half apply most of it with the planter. For Amish a system of bulk spreading is more cumbersome and time consuming than for non-Amish.

Average Fertilizer Application by Crops

The pounds per acre of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) applied on the average for crops and pastures grown by non-Amish and Amish are listed in Table 10.

Table 10. Pounds nutrients applied per acre by crop by non-Amish - NA and Amish - A. 1973

Crop	Acres	Grower's		Nutrients per A			Pct. in Manure Form		
		Class	No.	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Corn for Grain	2749	NA	40	115	78	88	0	0	0
	565	A	30	48	61	63	30	23	45
Corn for Silage	100	NA	1	230	202	200	85	50	100
	140	A	16	27	42	40	26	17	35
Soybeans	3088	NA	53	4	14	16	0	0	0
	0	A 1/	—	—	—	—	—	—	—
Oats	393	NA	21	32	32	36	0	0	0
	467	A	28	25	32	27	0	0	0
Wheat	495	NA	25	42	58	48	0	0	0
	149	A	13	27	41	31	0	0	0
Hay	60	NA	8	0	5	1	0	0	0
	628	A	30	24	21	37	68	79	88
Pasture	372	NA	12	0	0	0	0	0	0
	679	A	28	39	38	74	92	95	97
Totals:									
NA	7252	Average NA		53	44	48	—	—	—
A	2628	Average A		33	38	50	—	—	—
Grand Total:	9880								

1/ Soybeans not grown by Amish.

This indicates a higher nutrient application for corn grain and silage by non-Amish growers. The silage fertilization is so great because one grower applied 20 tons per acre of high quality manure plus a starter with P & K.

Amish apply more fertilizer of all types to pasture and hay than non-Amish.

Applications on oats are similar among the two groups. For wheat non-Amish apply a third more fertilizer than Amish.

Non-Amish apply 20 pounds more N and 6 pounds more P per average acre fertilized than Amish. The Amish apply 2 pounds more K per acre due probably to their heavy applications of manure which is relatively high in K.

Nitrogen applications should only be regarded as approximations, particularly as to N for Amish who use manure. There was no way to accurately estimate the N content of manures due to variable amounts of bedding used and care in handling in the barns and lots where it is normally stored. It is not clear how much of the N becomes part of the nutrient cycle on the land. A general value given for the dominantly dairy and beef cattle manures produced by Amish was 5 pounds N per ton. Amish farmers reported manure in loads per acre. An average manure wagon was assumed to hold 2 tons.

Average Fertilizer Application by Subwatershed

In Table 11 the total nutrients applied by subwatershed and the average gross acre application are listed. This will allow some degree of comparison between water sample analyses on certain reaches of the subwatersheds and average applications of manure and chemical fertilizer. See Table 10, page 9.

To obtain these data the responses to part I question 4 regarding crops grown and fertilizers used were later proportioned to one or more subwatersheds by estimating how much acreage of each farm occurred on each side of a subwatershed boundary. Then, assuming crops grown and fertilizers applied were distributed evenly in the same proportion as the total farm acreage, recalculations were made. This of course has a number of weaknesses. For one thing, there is no way to know actual land use by subwatershed. These data should be used only as a guide in later interpretation of water analyses.

Table 11. Nutrients applied by subwatershed. 1973[1]

Sub-watershed	Acres	N Pounds	N lb/A	P_2O_5 Pounds	P_2O_5 lb/A	K_2O Pounds	K_2O lb/A
SWS 1	1345	46,685	36	39,800	29	55,857	41
SWS 2	620	28,710	46	26,441	43	25,652	41
SWS 3	1170	53,644	46	41,026	35	40,997	35
SWS 4	2080	78,010	37	61,998	30	59,332	29
SWS 5	2194	84,485	38	68,349	32	81,875	37
SWS 6	4428	177,885	39	122,342	27	120,786	27
Total Watershed		472,319		418,121		479,560	

[1] Per gross acreage in subwatershed without regard to acreage on which actually applied.

Many Grades of Fertilizers Used

In the questionaire farmers were asked the grade of fertilizer or fertilizers used. For corn there were often 2 or 3 listed and enumerators tried to keep them in the order of application as #1, #2, etc. Analyses of grades used and the order in which they were reported for each crop are listed in Table 12.

Total fertilizer grades reported do not agree with the number of farmers reporting that they fertilized each crop in Table 8. For example, there are 11 short under fertilizer #1 for corn for non-Amish (28 of the 39 reporting use of fertilizer). Possibly this was due to coding erroneously as fertilizer 2 or 3. Only 27 of 30 Amish reporting use of fertilizer alone or with manure are included. For beans, 33 of 35 are included. For silage, 15 of 17 are included. For oats, only 22 of 28 Amish are included. Hay and pasture totals do not reflect manures applied. A wide range of fertilizer grades were used in 1973.

Of 40 non-Amish corn growers, 24 seem to be getting the main N supplies through grades like 82-0-0, 33-0-0, and 28-0-0 either as plowdown or sidedress. About 8 growers used high K grades probably as plowdown but evidently many are plowing down mixed grades containing considerable P and some N.

Amish rely mostly on mixed grades of 1-1-1 or 1-4-2 ratios with 19 reporting use of 1 fertilizer only or 1 fertilizer plus manure (Table 8) and only 3 of 30 growers list a high N source like 45-0-0 as top dress or plow down.

Bean growers are relying on low N, medium P and high K grades and all but one apparently applied these as side band with the planter.

Oats growers are relying strongly on 1-1-1 or 1-4-4 grades and only one reports using a high N source (33-0-0) as topdress.

Table 12. Chemical fertilizer grades applied by crops and by order of fertilization by non-Amish and Amish growers 1973. Analyses arranged by decreasing order of K_2O content.

Corn - Grain				Corn - Grain				Soybeans	
40 Non-Amish		30 Amish		40 Non-Amish		30 Amish		53 Non-Amish	
Fert #1	No. using	Fert #1	No. using	Fert #2	No. using	Fert #2	No. using	Fert #1	No. using[1/]
0-0-60	1	6-24-24	1	0-0-60	2[2/]	8-32-16	2	0-0-60	1[2/]
0-11-45	1	5-20-20	1	0-11-45	1[2/]	45-0-0	2	0-15-40	1[2/]
0-15-40	1	8-32-16	6	10-26-26	1			6-16-32	1
6-16-32	1	16-16-16	1	6-24-24	1			4-17-28	1
8-24-30	1	15-15-15	1	8-32-16	5			4-16-27	1
3-10-27	1	12-12-12	16	16-16-16	1			3-9-27	1
0-26-26	1	45-0-0	1	7-25-11	2			3-9-27	1[3/]
6-26-26	2			10-34-0	1			6-26-26	1
6-24-24	7			82-0-0	7			4-17-25	1
19-19-19	1			33-0-0	3			6-24-24	11
17-17-17	1			Fert #3	No. using			4-23-18	1
16-16-16	1							3-32-16	6
14-14-14	1			0-0-60	2[2/]			4-24-12	1
7-30-11	3			82-0-0	6			12-12-12	3
5-32-7	1			33-0-0	2			6-28-10	1
10-34-0	1			28-0-0	2			5-20-10	1
8-32-0	1								
82-0-0	1								
33-0-0	1								

Corn - Silage			
Fert #1	No. using	Fert #1	No. using
10-34-0	1	5-20-20	1
		8-32-16	3
		15-15-15	1
		12-12-12	8
		10-10-10	1

1/ 18 bean growers reported not using fertilizers

2/ Probably added as plowdown

3/ Reported as second fertilizer

Table 12 Continued

Oats				Wheat			
21 Non-Amish		28 Amish		25 Non-Amish		13 Amish	
Fert #1	No. using	Fert #1	No. using	Fert #1	No. using	Fert #1	No. using
6-24-24	3	19-19-19	1	6-20-28	1	6-24-24	1
19-19-19	2[3/]	16-16-16	1[3/]	6-26-26	1	8-32-16	3
16-16-16	9	8-32-16	3	6-24-24	6	15-15-15	2
15-15-15	1	15-15-15	4	8-16-24	1	12-12-12	6
14-14-14	2	12-12-12	18	6-20-20	1	45-0-0	1[2/]
12-12-12	3	10-10-10	1	8-32-19	1		
10-5-5	1			19-19-19	1[3/]		
33-0-0	1[3/]			16-16-16	4		
				8-32-16	3		
				14-14-14	2		
				12-12-12	2		
				12-12-12	1[3/]		
				6-12-12	1		
				28-0-0	5[3/]		
				33-0-0	6[3/]		

Hay				Pasture			
8 Non-Amish		30 Amish		12 Non-Amish		28 Amish	
Fert #1	No. using	Fert #1	No. using	Fert #1	No. using	Fert #1	No. using
0-32-18	1	6-24-24	1		0	15-15-15	2
		15-15-15	5			12-12-12	1
		12-12-12	2			45-0-0	1[3/]
		45-0-0	1				
		45-0-0	1[3/]				
		33-0-0	1[3/]				

[2/] Probably used as topdress.

[3/] Reported as second fertilizer.

Wheat growers are relying on grades with P and K generally balanced but 3 Amish growers and 4 non-Amish used grades higher in P than K which reflects a normal need for wheat. Topdressing wheat is reported by 13 non-Amish and only 1 Amish. They used a high N grade like 45-0-0, 33-0-0 or 28-0-0 in all but two cases where a 1-1-1 ratio containing considerable N was used.

Of 8 non-Amish hay growers only 1 used fertilizer. Eleven of 30 Amish used 1-1-1 or 1-4-4 grades or a high N fertilizer to stimulate production.

Pastures are not fertilized by non-Amish and much land reported by them as pasture may have been lay out land included in a farm program in 1973. Only 4 Amish reported fertilizing chemically and 17 used manures only (Table 8). One topdressed pasture with 45-0-0 and 3 used 1-1-1 grades.

Suggestions for Follow-up Questionaire

A second questionaire to update information on practices and precepts of landowners should be more carefully structured to allow correct interpretation in areas of land use, cropping, fertilizing and pesticide use. This is essential if such data can be expected to indicate probable sources of chemical or organic pollution for runoff waters from the various subwatersheds. A person familiar with farm practices would be a useful addition to each interview team. We are now cooperating with persons designing the next questionaire.

One example of a difficult question was that on herbicide use. Dry ingredientsper quart of formulation vary by herbicides. (Aatrex and Aatrex + Bladex - 1-1/4 lb/qt.; Aatrex + Lasso - 4 lb/qt.; Lasso + Banvel - 6 lb/qt.; Ramrod - 4.3 lb/qt.; Ramrod + 2,4,D - 1.7 lb/qt.; 2,4,D = 1 lb/qt.; Amiben + Lasso - 3.3 lb/qt.; Lasso - 6.7 lb/qt.) Since some growers use dry form measured in pounds, question asked in quarts was probably difficult to convert.

SEDIMENT CONTRIBUTIONS TO THE MAUMEE RIVER

by

E. J. Monke, D. B. Beasley and A. B. Bottcher

The annual long term sediment yield from the Maumee River into Lake Erie is estimated at 1,800,000 t or, in terms of the basin area, approximately 1000 kg/ha (1). Erosion losses of this magnitude from agricultural lands are low and not particularly detrimental to their productivity. However, because of location, the resulting sedimentation rates are contributing to the deterioration of water quality in Lake Erie. Sediments in most streams in the Maumee River Basin are highly colloidal in nature and the streams remain murky almost continuously. Since the sediments are mostly colloidal materials they also have a high capacity for transporting chemicals notably phosphorus which is likely the limiting element in the eutrophication process.

The comparatively low erosion losses from agricultural lands in the Maumee River Basin may be difficult to further reduce, still maintaining their present productivity level. Storm events, having thirty percent of the annual erosion potential (2) for this region, occur during May and June during which time extensive land areas are either bare or only partially protected with vegetation. Also surprisingly large amounts of sediments, estimated as high as one-half the annual rate, originate from subsurface drains which underlay most of the basin. For these reasons, the sources of erosion must be carefully identified, the relative magnitude of their contribution to the sediment loadings of the basin streams determined, and select control measures initiated which give the greatest reduction in sediment yields with a minimal disruption to production.

In this paper, we will discuss sediment yields from the Maumee River into Lake Erie, sediment yields from the Black Creek Watershed into the Maumee River, contributing factors causing erosion in the watershed, and finally, a plan for relating the erosion-sedimentation process to land use.

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SEDIMENT YIELDS INTO LAKE ERIE

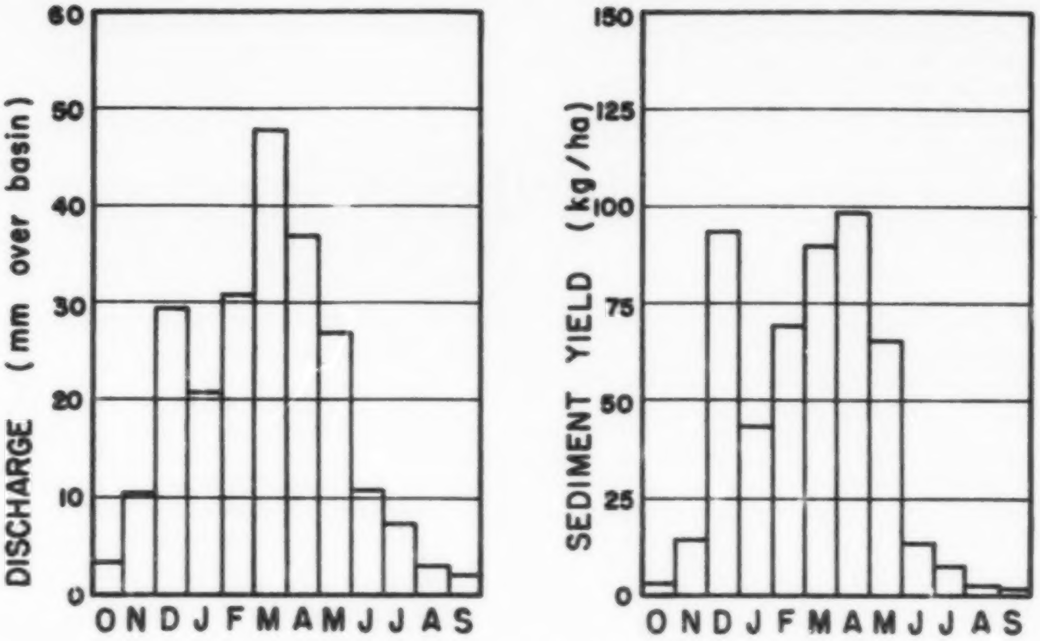
An analysis of sediment yields from the Maumee River into Lake Erie and concurrent rainfall amounts over the basin will give an understanding of the nature and magnitude of the sedimentation problem. Comparison of sediment yields into Lake Erie with those from the Black Creek Watershed into the Maumee River can then be made although a scaling factor both in time and space should be taken into account. The Maumee River Basin contains 1,711,500 ha of mostly agricultural lands while the Black Creek Watershed contains only 4900 ha also mostly agricultural lands. Maximum responses of the watershed and basin differ, however, according to the type of storm which is likely to cover these areas. Convective-type storms with high intensities can cover the watershed area while only frontal-type storms with lower intensities than those occurring over the watershed are likely to occur over the basin. Many of these latter storms also occur in the winter months when the ground may be frozen.

Data on sedimentation rates in the Maumee River at Waterville, Ohio and rainfall rates over the basin were provided by the United States Geological Survey and the United States Environmental Data Service, respectively (3, 4). The results of an analysis of this data for a 10-year period, October 1961 to October 1971, are shown in Table 1 and Figure 1. The average annual precipitation and discharge from the Maumee River as measured at Waterville, Ohio, both expressed as depths over the basin, were 808 and 203 mm, respectively. These values are only slightly below the reported values for the total length

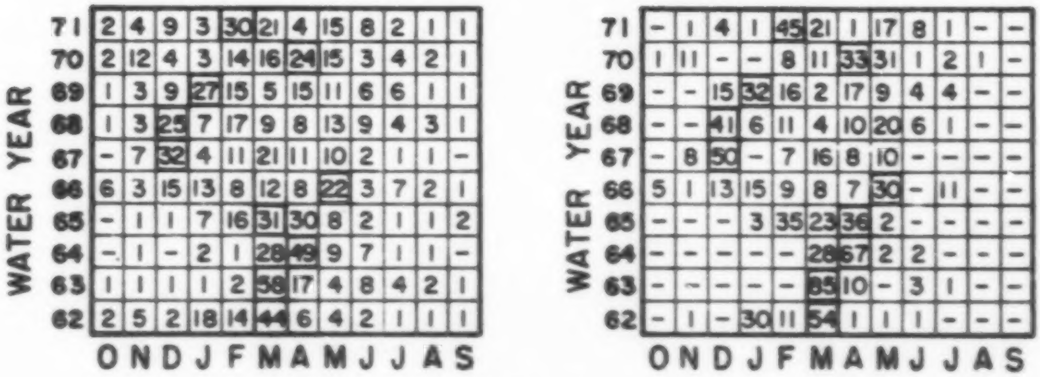
Table 1. Average Annual Precipitation for the Maumee River Basin and Annual Sediment Yield and Discharge from the Maumee River for a Ten-Year Period, October 1961 to October 1971.

Water Year	Precipitation[a] (mm)	Discharge (mm over basin)	Ratio of discharge and precipitation (%)	Sediment yield (kg/ha)
1970-71	739	198	27	304
1969-70	898	267	30	609
1968-69	938	320	34	662
1967-68	980	345	35	989
1966-67	835	348	42	763
1965-66	807	181	22	202
1964-65	826	196	24	516
1963-64	716	150	21	427
1962-63	656	109	17	159
1961-62	683	186	27	323
Average	808	230	28	495

[a] Average of three locations: Fort Wayne, Defiance and Toledo.



(a) Average monthly discharge (left) and sediment yield (right)



WATER YEAR	O	N	D	J	F	M	A	M	J	J	A	S
71	2	4	9	3	30	21	4	15	8	2	1	1
70	2	12	4	3	14	16	24	15	3	4	2	1
69	1	3	9	27	15	5	15	11	6	6	1	1
68	1	3	25	7	17	9	8	13	9	4	3	1
67	-	7	32	4	11	21	11	10	2	1	1	-
66	6	3	15	13	8	12	8	22	3	7	2	1
65	-	1	1	7	16	31	30	8	2	1	1	2
64	-	1	-	2	1	28	49	9	7	1	1	-
63	1	1	1	1	2	58	17	4	8	4	2	1
62	2	5	2	18	14	44	6	4	2	1	1	1

WATER YEAR	O	N	D	J	F	M	A	M	J	J	A	S
71	-	1	4	1	45	21	1	17	8	1	-	-
70	1	11	-	-	8	11	33	31	1	2	1	-
69	-	-	15	32	16	2	17	9	4	4	-	-
68	-	-	41	6	11	4	10	20	6	1	-	-
67	-	8	50	-	7	16	8	10	-	-	-	-
66	5	1	13	15	9	8	7	30	-	11	-	-
65	-	-	-	3	35	23	36	2	-	-	-	-
64	-	-	-	-	-	28	67	2	2	-	-	-
63	-	-	-	-	-	85	10	-	3	1	-	-
62	-	1	-	30	11	54	1	1	1	-	-	-

(b) Monthly percentage of yearly discharge (left) and sediment yield (right)

Fig. 1. (a) Average Monthly Discharge and Sediment Yield for the Maumee River, and (b) Monthly Percentage of Yearly Discharge and Sediment Yield, both for a Ten-Year Period, October 1961 to October 1971.

of record. However, the average annual sediment yield, again in terms of basin area, was only 495 kg/ha. This value is about one-half the normally accepted value of 1000 kg/ha for sediment yield. Since the normally accepted value was never exceeded in any of the ten years which were analyzed, one is lead to suspect that this value is high. If this is true, the task of further reducing an already relatively low sedimentation rate is compounded.

The precipitation amounts for the 10-year period seem to be part of a cyclical pattern. Less than normal precipitation occurred from 1961 to 1966 and above normal precipitation from 1967 to 1971. The years with the highest precipitation amounts not only had the highest discharge rates but also the highest percentage of precipitation occurring as river discharge. As a result, the average annual sediment yield for the last five years was 665 kg/ha, more than twice the 324 kg/ha yield for the first five years.

Years with above normal precipitation usually had heavy winter storms. These storms then produced some of the highest monthly percentages of yearly discharge and sediment yield as shown in Figure 1(b). The initial major storm during this period flushed out residual sediments which had been accumulating in the Maumee River system.

SEDIMENT YIELDS FROM THE BLACK CREEK WATERSHED

Sediment yields from the Black Creek Watershed into the Maumee River are being determined by integrating sediment concentrations and flow rates. Water quality sampling sites, stream stage recorder sites and also raingage locations are shown on Figure 2, an outline map of the watershed. Most of the sampling and stage recorder sites are located in the lower portion of the watershed particularly where the tributary drains enter into the main stem of Black Creek.

Procedure for Evaluating Sediment Yield

Stage-discharge relationships are being developed for the six principal tributary drains which enter into Black Creek to give flow rates. Water levels are continuously recorded at these locations with a pressure-type recorder (Model 12 Flow Recorder, Foxboro)*.

Water samples for determining the concentration of sediment as well as other quality parameters are being collected either manually or with automated samplers. Grab samples are routinely collected each week and then at select times usually following a storm event. The automated samplers are triggered at a set minimal stage and continue to operate automatically until the sampling capacity is exhausted. Usually, however, the water samples are collected and the automated sampler reset before this happens.

Automated Samplers: Three automated pumping samplers (PS-69, developed by the U. S. Interagency Sedimentation Project) were installed

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*The product description and manufacturer are given for reader information and should not be construed as an endorsement of the product.

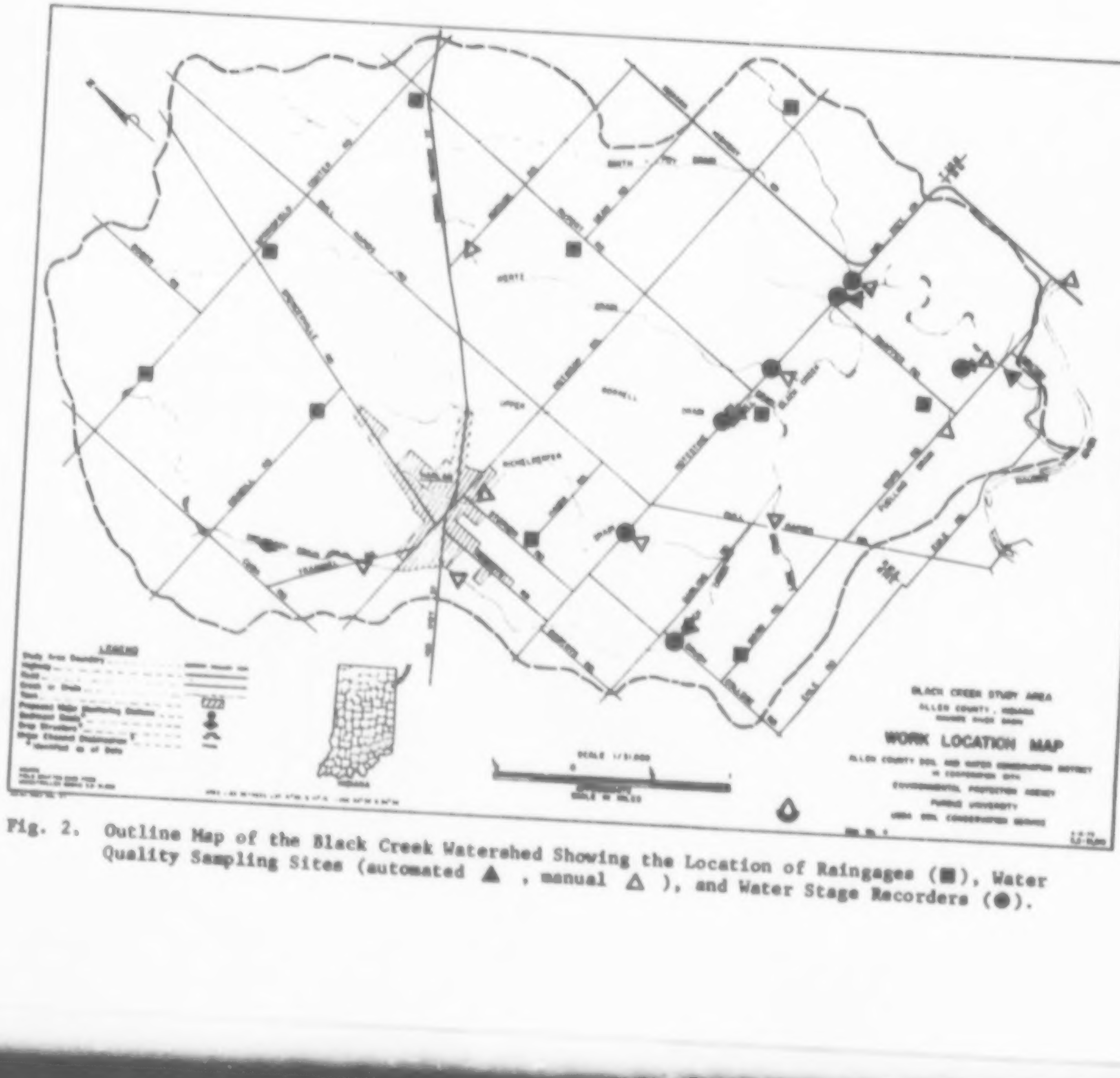
BLACK CREEK STUDY AREA
ALLEN COUNTY, INDIANA
WORK LOCATION MAP
ALLEN COUNTY SOIL AND WATER CONSERVATION DISTRICT
IN COOPERATION WITH
ENVIRONMENTAL PROTECTION AGENCY
PURDUE UNIVERSITY
USDA SOIL CONSERVATION SERVICE
LEGEND
INDIANA

Fig. 2. Outline Map of the Black Creek Watershed Showing the Location of Raingages (■), Water Quality Sampling Sites (automated ▲ , manual △), and Water Stage Recorders (●).

on two of the largest tributary drains into Black Creek and on the main stem of Black Creek near its entrance into the Maumee River. Each sampler is capable of automatically collecting 72 samples on a set time interval. At the present time, a 500 ml water sample is collected every 30 minutes after the sampling sequence has been initiated. Samples are being collected from the suspended sediment profile of the streams near the elevations at which the automated samplers are triggered.

Another automated sampler similar to the PS-69 sampler has been developed by the Department of Agricultural Engineering at Purdue University to monitor the discharge from a 63-acre, uniformly spaced tile drainage system on Hoytville silty clay loam. Hoytville silty clay loam is a lake plain soil and occupies a considerable portion of the lower Black Creek Watershed. The sampler has the capability of collecting 72 samples on a constant volume passed basis. The sampling rate varies linearly from 30 minutes at maximum flow to zero at no flow. A 350 gpm pump in conjunction with a sump has been installed to prevent the tile outlet from being inundated during storm events.

Sediment Yields, 1974-75

The hydrologic year, October 1974 to October 1975, was the first year during which complete records were obtained. The automated samplers became operational early enough in 1975 to sample most of the major storm events during the year, 1974-75. The sediment yield for the Black Creek Watershed was 1750 kg/ha of which about two-thirds occurred during May. Most of the sediment yield during May was also the result of one storm which occurred in the early morning of May 20. An average of about 90 mm of rainfall then fell over the entire watershed in two hours. Rainfall frequencies based on the rainfall intensity-frequency data analyses by Yarnell (5) were estimated from 50 to 100 years at the raingage locations. For the year, 1095 mm of precipitation occurred over the Black Creek Watershed and approximately 320 mm or 29% of this amount was discharged into the Maumee River. A comparison of these values with those in Table 1 for the Maumee River Basin shows precipitation and discharge from the Black Creek Watershed are high, the ratio of discharge to precipitation about the same, and the sediment yield approximately four times the average yield from the Maumee River for the 10-year period, 1961-71. While records for the Maumee River Basin for 1974-75 are not yet available, the relatively high sediment yield from the Black Creek Watershed during May probably did not affect the rate of sediment yield into Lake Erie much at all. However, this sediment is now in a stream system which is largely in a dynamic equilibrium state and eventually most of the sediment will reach Lake Erie.

Tributary Drains: In general, sediment contributions from the tributary drains into Black Creek showed a close similarity one to another. Pumping samplers are located on the Driesbach and Smith-Fry Drains which permit a more detailed analysis to be made than with the other drains. These drains are two of the major drains entering Black Creek and are also probably the most contrasting with regard to soil types and land use. Characteristics of these drains are given in Table 2.

Table 2. Characteristics of Smith-Fry and Driesbach Drains

Characteristics	Smith-Fry	Driesbach
Watershed area	890 ha	735 ha
Channel gradient	0.35%	0.39%
Soils:		
Lake plain and beach	71%	26%
Glacial till plain	29%	74%
1974-75 land use:		
Small grain and pasture	26%	44%
Woods	8%	4%
Urban, roads, etc.	3%	12%
Row crops	63%	40%

The monthly precipitation in mm, discharge volumes in mm over a watershed, and sediment yields in kg/ha for Smith-Fry and Driesbach Drains are given in Figures 3 and 4. Total amounts for the year are given in Table 3.

Table 3. Total Precipitation, Discharge Volumes and Sediment Yield for the Smith-Fry and Driesbach Drains, 1974-75

Drain	Precipitation (mm)	Discharge volume (mm)	Ratio of discharge and precipitation (%)	Sediment yield (kg/ha)
Smith-Fry	1090	350	33	1750
Driesbach	1100	290	26	1750
Average[a]	1095	320	29	1750

[a]Used for Black Creek Watershed totals

The differences in total precipitation, discharge volumes and sediment yields between the Smith-Fry and Driesbach Drains were only slight and so the monthly amounts show virtually identical patterns for the year. The primary difference between the two drains was in discharge volume and then in the ratio of discharge and precipitation. For the year, 33 percent of the total precipitation on the drainage area for the Smith-Fry Drain was discharged into Black Creek while only 26 percent of the total precipitation was discharged by the Driesbach Drain. Although the drainage area for the Driesbach Drain has more rolling topography than for the Smith-Fry Drain, the latter is more extensively tile drained. With similar sediment yields, the concentration of sediments was highest in the Driesbach Drain. In fact, for all normal and low flows, the Driesbach Drain carried considerably more sediments and also a correspondingly greater phosphorus loading than the Smith-Fry Drain. In contrast, except for high flows, the Smith-Fry Drain carried less sediments and phosphorus than the

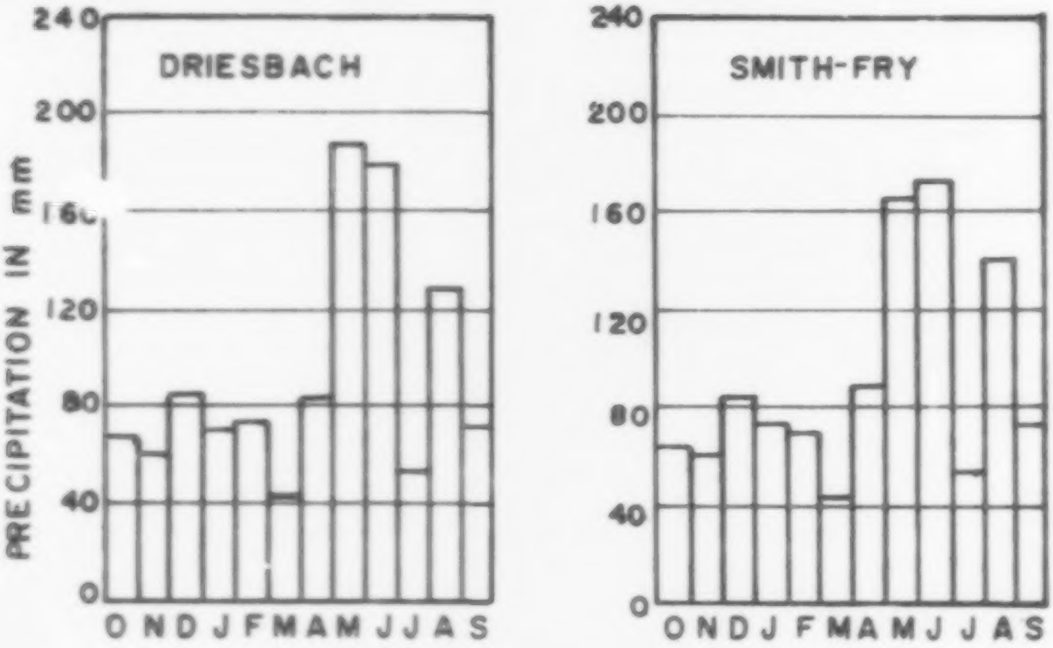

Fig. 3. Monthly Precipitation in mm, 1974-75.

Driesbach Drain, but incidently more nitrogen. The difference in nitrogen loading probably resulted from more of the drainage area put into row crops, a higher level of management, and more tile drainage than for the land which contributes runoff to the Driesbach Drain.

Approximately two-thirds of the drainage area for the Smith-Fry Drain is in the nearly level lake plain. For the storm of May 20, much of this level land also became a flood plain. Existing drains were overtopped, temporary new drainageways were established, and extensive flood plain scouring occurred. Under such circumstances, erosion rates from the more level lake plain may equal or exceed erosion rates from the more rolling glacial till plain. This flooding also interferred with sediment sampling and increased the error associated with the determination of flow rates. The values given for Black Creek and the Smith-Fry Drain are believed to be somewhat conservative in this regard. For the future, velocity meters will be installed at the automated sampling stations on the Smith-Fry Drain and Black Creek. Also, the return periods of storms at which the principal drains can be expected to overtop will be calculated.

Sediment Contribution from Tile Drains: Subsurface drainage sys-

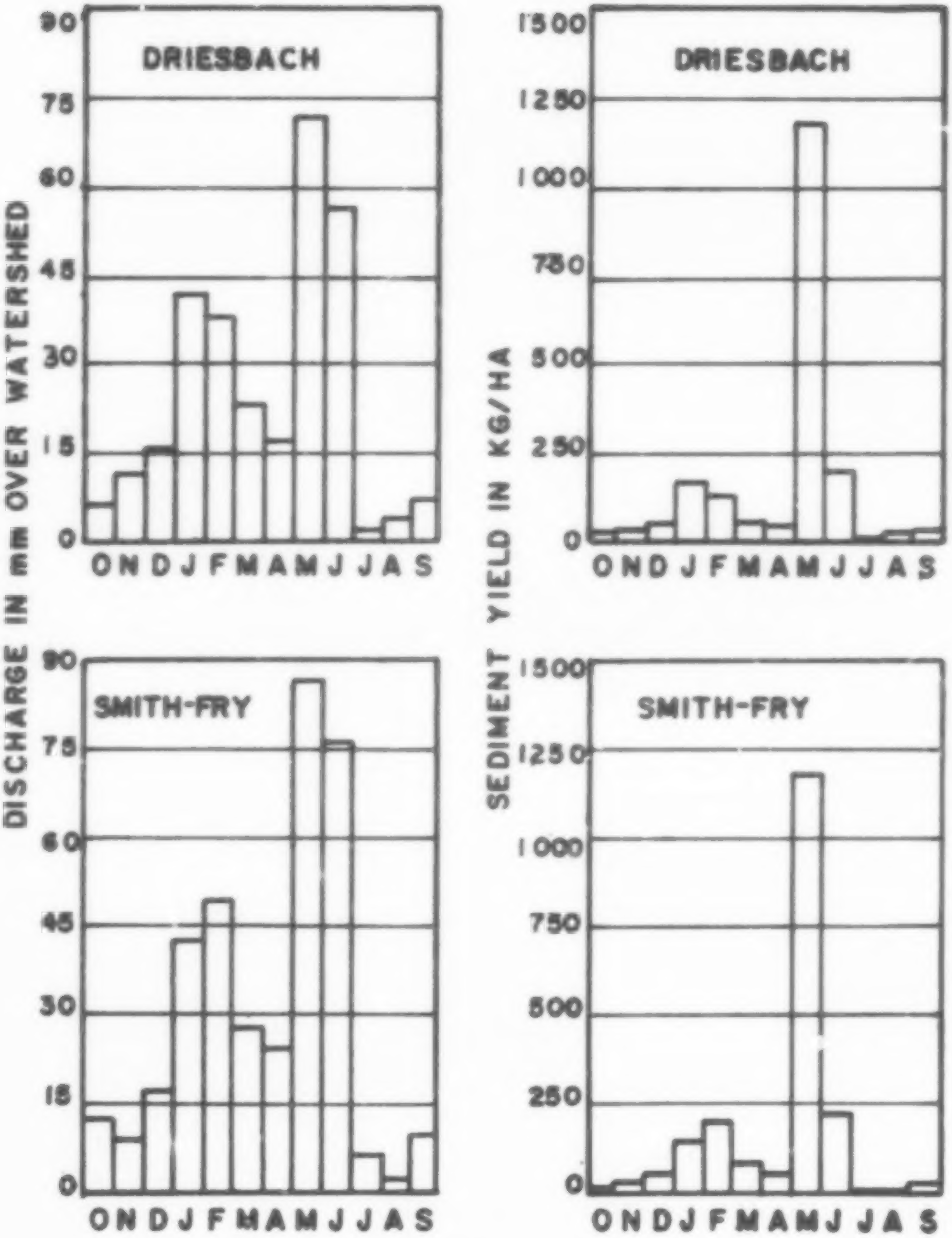

Fig. 4. Monthly Discharge in mm over a Drainage Area (left) and Sediment Yield in kg/ha (right), 1974-75.

tems have been installed over a large portion of both the Black Creek Watershed and the Maumee River Basin. The first tile drains were installed perhaps 75 to 100 years ago. In general, these were mostly random drains which drained the most troublesome wet areas first. Later additional tile drains were connected to these random systems to extend their coverage. Then complete uniform systems with drain spacings on the order of 15 to 20 m were installed usually in the lake plain soils. Often when a new system replaced an older one, many of the drain lines in the old system which appeared to be still functioning were connected to the new system. As a rule, poor records of the extent and location of all the subsurface drainage systems have been kept. In addition, the state of repair of the tile drains as related to their flow capacities is also largely unknown.

In the Black Creek Watershed alone over 750 tile outlets have been identified. Samples of tile drain effluent were collected from all the drains which were flowing during the period, May 13 to June 7, 1974. In general, sediment concentrations were low but rainfall during this period was light and sampling was usually accomplished during the fair days. From all the tile outlets, 20 were selected for further sampling. An analysis of sediment concentrations in the effluent from these till outlets for the period, April 4 to June 12, 1975 is presented in Table 4. The probable soil types drained were Hoytville silty clay loam, Haskins silt loam, Pewamo silty clay loam, and Rensselaer silt loam. The first two soils are lake plain soils, Pewamo silty clay loam and its closely associated Blount silt loam are till soils, and Rensselaer silt loam is connected with the beach ridge which parallels State Route 37 through the watershed.

All flows contained some sediments. The minimal concentrations were low and the range of concentrations small. The maximum sedimentation concentrations, however, contained some very high values. The range of concentrations was also large leading one to suspect that many maximum events were missed. The median sediment concentrations were low and consistent with both location and soil type. The average median sediment concentration could well represent the base flow condition for tile drainage in the watershed. The mean sediment concentrations were affected by maximum events if such an event happened to be sampled. A reliable value for mean sediment concentration is needed in order to calculate sediment yield. While the considerable variation in mean sediment concentrations rules out the calculation of sediment yield, the high values for some of the mean sediment concentrations indicate that tile effluent may be a significant contributor to sediment yield from the Black Creek Watershed. An average annual sediment yield of 875 kg/ha has been reported for a lacustrine soil in another part of the Maumee River Basin (6).

Two major problems hinder manual sampling of tile effluent. Maximum sediment yield may occur during or shortly after a storm event, and outlets may be submerged. Specially designed automated tile samplers similar to the one described in this paper are required to give proportional samples for calculating sediment yield and the tile discharge hydrograph. A companion project in Ohio has also been initiated to determine annual sediment yields from tile drains in a number of Maumee River Basin soils (7).

Table 4. Analysis of Sediment Concentrations in Effluent from Select Tile Outlets, April 4 to June 12, 1975.

Probable soil type drained	Nominal outlet size (cm)	Sediment concentration in mg/l			
		Minimum	Maximum	Median	Mean
Hoytville silty clay loam	15(6")	50	78	63	64
	20(8")	34	98	86	77
	20	79	932	85	237
	20	40	148	79	88
	25(10")	35	183	60	73
	30(12")	44	124	92	87
	30	51	122	70	73
	30	70	192	120	122
	30	33	67	63	60
Haskins silt loam	25	60	512	72	126
Pewamo silty clay loam	25	51	12900[a]	76	1750
	25	28	610	62	162
	25	43	66	49	51
	38(15")	31	291	81	100
	46(18")	54	1130	79	205
Rensselaer silt loam	15	42	2880	84	546
	20	63	113	84	87
	25	75	7240	86	886
	25	57	144	87	87
Average		47	1390	73	250

[a] Probable surface inlets from Harlan

CONTRIBUTING FACTORS TO SOIL EROSION

For the year 1974-75, the primary contributing factor to erosion in the Black Creek Watershed was the large amount of bare soil surfaces which were exposed to intense storms during late May and early June. Over one-half of the watershed area is normally in rowcrop cultivation. In late May and early June, all of this land had either been recently worked or planted to crops. Over one-half of the total sediment yield of 1750 kg/ha for the entire year occurred from May 20-22 alone. During this period, the outlet drains overtopped onto the nearly level lake plain soils causing severe soil erosion. Ordinarily very little surface erosion would be expected from these lands which cover approximately the lower one-half of the watershed.

The annual streambank erosion from the Black Creek Watershed has been estimated at 9 kg/ha (8). This erosion is directly available for transport in the stream system of the watershed. More streambank erosion undoubtedly occurred during the year 1974-75, but even if the average value was escalated tenfold, it would still represent only a small percentage of the total sediment yield to the Maumee River.

Tile drainage effluent may contribute significantly to the sediment yield from the Black Creek Watershed. However, it is difficult to separate out, even under the most favorable conditions. Low level tile flows with sediment concentrations similar to the median sediment concentration values given in Table 4 would deliver around 100 kg/ha/year from the tile drained lands. With the additional effects of initial and high flows, the annual sediment yield from the tile outlets in the watershed would probably be three or four times the base delivery rate. Again this erosion is directly available for transport in the stream system of the watershed.

Seepage pressures occur when the soil above tile drains becomes saturated and flow into the drains then occurs along with some sediments. However, the mechanics of the soil detachment process is not well defined. It is not known if backward erosion causes segments of the total soil matrix near the openings into the drains to be moved into the drains where separation of the finer from the coarser sized particles would then take place, or if this separation essentially occurs in the soil matrix surrounding the drains first and then moves through the soil pores or structural cracks to the drain openings. In Hoytville silty clay loam, a lake plain soil, downward fingers of topsoil into the subsoil would seem to indicate the latter occurrence. Probably the mechanism is a combination of both processes, however, if not others also.

The tile drains on the watershed have been observed to sometimes flush large quantities of drainage water into streams during the winter and early spring months. This occurrence is primarily dependent on temperature although rainfall which probably occurs at the same time may increase the discharge. When the soil surface freezes, a surface seal is formed which transfers free soil water above the tile drains into a negative pressure state. Tile discharge for all practical purposes stops although downward movement of water in the soil may still take place. Then when thawing occurs, the drains seem to flush. High seepage pressures may also simultaneously occur causing movement of sediments into the drain. Many freeze-thaw cycles often occur at this latitude during the winter-early spring months of the year.

RELATING SEDIMENT YIELD TO LAND USE

Sediment yield from the Black Creek Watershed can be related to land use in general terms. However, it is difficult to determine sediment yield reductions for specific watershed practices which are designed to give some degree of erosion control. Most of these practices cover only a small portion of the watershed. Additional lands are being improved but at a slow rate and in irregular patterns. Also the effectiveness of some erosion control practices greatly depends on management level. Then rainfall occurs in an unsteady, nonuniform manner over the watershed. And finally the measurement of rainfall and the resulting runoff and sediment yield is subject to considerable error.

A distributed watershed model is being developed to show the relationship between sediment delivery to streams and land use. A distributed model which sums up the effects from small areas has been proposed because land use is highly variable over most watersheds and its relation to erosion is further compounded by differences in soil types, cropping sequences and managerial abilities. Such a model also has the ability to account for rainfall valuability over the watershed. The model is based on a coupling of the equation of continuity for sediment transport with equations describing the water flow process. A reaction equation for sediment transport may also be included to avoid abrupt changes in sediment concentrations.

The equation of continuity for sediment transport is

$$\frac{\partial G}{\partial x} = D_r + D_i + D_s \qquad (1)$$

where G is the sediment load (weight/time/unit width of slope), x is the slope distance, D_r is the detachment or deposition rate of rill erosion (weight/time/unit area), D_i is the delivery rate of particles from interrill erosion to the rill system (weight/time/unit area), and D_s is the detachment rate of particles due to seepage pressures (weight/time/unit area). This equation was proposed by Foster and Meyer (9) except for the term D_s which was added to account for sediments from tile drains.

The first order reaction equation also proposed by Foster and Meyer is

$$D_r = \frac{D_c}{T_c} (T_c - G) \qquad (2)$$

where D_c is the ultimate detachment capacity of rill flow and T_c is the ultimate transport capacity of the rill flow.

The terms D_c, T_c, D, and D_s in eqs. (1) and (2) can be evaluated separately since these terms are defined by rainfall and runoff characteristics and soil properties. On the basis of empirical evidence, $T_c \propto \tau^{3/2}$ and $D_c \propto T_c$. D_i can be assumed proportional to the square of rainfall intensity and D_s is a function of seepage pressure. The two remaining unknowns are then D_r, the detachment rate by flow in rills, and G, the sediment load.

The equations describing the water flow process are the standard equation for free flow in an infinitely wide channel,

$$\frac{\partial y}{\partial t} + u \frac{\partial y}{\partial x} + y \frac{\partial u}{\partial x} = \sigma \qquad (3)$$

and a uniform flow equation,

$$q = \alpha y^n \qquad (4)$$

where y is the depth of flow, u is the flow velocity, x is the distance in the direction of flow, t is time, σ is the net distributed water inflow, q is the flow rate per unit width and α and n are a coefficient and exponent for the uniform flow equation.

These equations then form the basis for modeling the erosion-sedimentation process. They are applicable to any point in a watershed and their rigor at least matches the uncertainty connected with friction loss, infiltration rates and the other hydrologic phenomena being modeled.

With the Black Creek Study, the modeling process will be closely linked to field experimentation in which observations of the erosion-sedimentation processes will hopefully lead to improvements in the model. Sensitivity analysis can also be performed to determine to what extent given soil and water management practices must be applied in order to affect a significant reduction in sediment yield. The sensitivity analysis will also help to identify those aspects of the system where more information is needed before system performances can be adequately predicted (10).

Finally, the erosion-sedimentation model might be useful in predicting the average annual sediment yield from the Maumee River into Lake Erie. The sediment yield phenomena can usually be divided into the upland and in-channel phases. While sediment transport in the upland phase is closely related to storm events, transport in the in-channel phase is not greatly affected by individual storm events except as a supply source (11). A valid assumption for this study might be that the main channels in the Maumee River Basin are essentially in dynamic equilibrium. In support of this assumption, the annual suspended sediment load of the Maumee River and its tributaries has been found to be predominately surficial in origin (12). It can now be argued that the average annual sediment yield into Lake Erie, except for man-made traps, equals the average annual erosion rate into the main channels of the entire basin. A summation then of the sediment yields from all the upstream source areas such as the Black Creek Watershed could be determined using the erosion-sedimentation model and an average annual sediment yield predicted for the basin.

SUMMARY

For the year 1974-75, the sediment yield from the Black Creek Watershed into the Maumee River was 1750 kg/ha. One major storm event in late May caused over one-half of the total sediment load. Since many drains were the overtopped, flood plain scouring of the nearly level portions of the watershed contributed a normally disproportionate share to the sediment loadings of the streams. An erosion-sedimentation model was proposed for relating the erosion-sedimentation process to land use and as a predictive tool for the total Maumee River Basin.

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STREAMBANK STABILIZATION

by

Rolland Z. Wheaton[1]

Many streams are carrying large annual loads of suspended materials. The source of these materials have been stated to be agricultural operations, construction activities, streambank erosion, urban areas and so forth. To determine the possible extent of the streambank erosion in the Black Creek Watershed, four sub-studies were initially proposed. These studies are, (1) a soil mechanics streambank stabilization evaluation, (2) an evaluation of changes naturally occurring in channels, (3) an evaluation of the effects of streambank slope and mulch materials on establishing vegetation after reconstruction, and (4) an evaluation of the effectiveness of various structural measures installed for the reduction of stream channel erosion.

Studies 1 and 3 have been completed and study 2 has been redesigned to be an evaluation of a degradation taking place [illegible] channel reaches. Study 4 is being continued. In addition to these four sub-studies, a complete survey was made in 1975 of the streambank erosion in the watershed. This study was conducted by SCS personnel as a part of the International Joint Commission PLUARG study in cooperation with the Black Creek Project.

Soil Mechanics Streambank Stability Studies

This study was conducted by Doug West, a former graduate student at Purdue University.[2] The Soil Conservation Service had taken soil samples at 13 sites in August 1973. These samples were analyzed in their Lincoln, Nebraska laboratory. The results of these analysis showed that the stream channels were generally safe from failure by shear at slopes as steep as 1:1. Looking at the profile of these analysis, it is obvious that often the most cohesive soils (more erosion resistant) were near the surface, while the least cohesive soils may be near the channel bottom or distributed in bands within the profile. Also from an erosion standpoint, the banks are usually covered with vegetation while the bed is bare.

To analyze the erosion resistance of the stream channels, the allowable velocities approach was used. (SCS Tech. Report 25, 1964.) This approach considers the plasticity index and the sieve size that passes 75% of the material to determine the maximum nonerosive or "safe" velocity. Using the physical characteristics of the channel cross section and its grade, the carrying capacity of the channel is computed at successively increasing depths of flow until the allowable velocity is reached. At each step the channel capacity at each depth is compared with the runoff previously determined for the area above the channel cross section. For purposes of this study, the runoff rate for this six hour five year storm was used.

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[1] Associate Professor, Agricultural Engineering Department, Purdue University.

[2] Douglas A. West, "A Preliminary Investigation into the Stability of Streambanks in the Black Creek Basin." M.S. Thesis, May 1974.

If the carrying capacity of the channel at the allowable velocity equalled or exceeded the runoff rate, the channel was considered to be stable. If, however, the runoff rate exceeded the safe carrying capacity of the channel, the channel was unstable. As the study progressed, only five of the sites proved to be totally adequate for analysis. These sites were (1) the Reichelderfer Drain near Stopher Road, (2) the Upper Gorrell Drain near Highway 37, (3) Smith-Fry Drain at Notestine Road, (4) Smith-Fry Drain at Highway 101, and (5) Upper Gorrell Drain at Notestine Road. Sites 1 and 2 are in what might be called the transition area between the rolling upland and the lakebed soils. Sites 3, 4 and 5 are in the lakebed type soil area.

The sites identified above as 1 and 2 were found to be unstable primarily because of excess channel slope, although at one site on the Upper Gorrell near Highway 37 the channel had eroded into a bed of sand thus making it even less stable. On the other hand, sites 4, 5, and 6 were found to be stable primarily because of less channel slope and also of more cohesive soils.

This study indicates that the stream channels in the upland and transition areas are apt to be in an unstable condition primarily because of slope and less cohesive soils while channels in the lakebed area are more apt to be stable with lower channel gradients and more cohesive soils.

Naturally Occurring Changes in Channel Cross Section

Initially, five sites, three plus the two in the mulch study areas, were to be evaluated. Two of the sites were soon invalidated because of channel work to reduce erosion, and the third was lost to highway construction. Nevertheless, the short period of observation along with the soil mechanics study has shown the need to study the channel degradation. Four locations are now being observed to determine the rate of which channel scour may be taking place. One of these, the Upper Driesbach on the Joe Graber farm, has shown a lowering of one to two feet between 1973 and 1975. Stone drop structures to reduce the channel grade have now been installed in this location. Measurements at the other sites are only about one year old and results are not available at this time.

Ditch-Bank Slope Mulch Studies

To determine the effect of various bank slopes and mulch materials in establishing vegetation and controlling erosion, two sites were selected. One on the Upper Driesbach Drain on the Joe Graber farm and one on the Lower Wertz Drain between Notestine Road and Black Creek. Each treatment area consisted of a 50 foot reach on both channel banks. The treatments were 2:1, 3:1 and 4:1 bank slopes with mulch materials of straw, wood chips, stone and check. In addition, saw dust and a chemical soil stabilizer were used on the Driesbach Drain.

The mulch materials were applied as follows:

Stone, No. 4 crushed limestone, 135 tons per acre
Wood Chips, green wood chips, 10 tons per acre
Straw, 1-1/2 tons per acre
Check, no mulch
Saw Dust, 50 to 75% ground cover
Chemical Soil Stabilizer, applied by company representative in two applications because of initial errors. Total application unknown

The banks were seeded immediately after shaping with 35 pounds per acre of Kentucky No. 31 tall fesque and 5 pounds per acre of red top.

The ditch banks on the Driesbach Drain were shaped during reconstruction in the fall of 1973, seeded and mulched. The Wertz Drain was shaped and seeded in April of 1974. The straw mulch was applied immediately, but application of the wood chips and stone mulch was delayed approximately one week because of wet soil conditions.

Results of the evaluation of the mulches in controlling erosion and aiding the establishment of vegetation are shown in Tables 1 and 2. The data show that all mulches were effective in controlling erosion and were very beneficial in establishing the grass cover. There is no consistent difference between the treatments, however, the stone mulch was slightly superior in controlling erosion. High water in May 1974 washed away the straw and wood chip mulches on the Wertz Drain. The poor early germination and grass stand on the Wertz Drain for the stone and wood chip mulch is undoubtedly due to the delay in the application. All mulch plots were superior to the check plots in early establishment of grass.

The 3:1 slopes appear to be slightly better than the 2:1 and 4:1 slopes. The good performance of the 3:1 slopes on the Driesbach is undoubtedly due to the better soil conditions as the 2:1 and 4:1 slopes were established on areas of more severely eroded banks. These plots still shown the lack of fertility. Two to one slopes can be maintained by mowing, but it would be easier to maintain the 3:1. There is no distinct advantage shown for the 4:1 slopes to justify the additional area that is required for this slope.

Several major flows have occurred since establishment of the vegetation in the plots. The flow in May of 1975 was the result of a rainstorm of at least 100 years frequency. The grass vegetation protected the banks from damage although the channel bottom in the 4:1 slope on the Driesbach Drain had degraded as was discussed in the previous section.

This study shows the definite benefit of using a mulch material in the early establishment of the grass cover. All mulch materials were adequate in establishing grass and in controlling erosion, although the

Table 1. Driesbach Drain, Graber Farm

Mulch	Slope	12-12-73		4-2-74		5-28-74		5-2-75	
		E.C.	Cover	E.C.	Cover	E.C.	Cover	E.C.	Cover
Stone	2:1	G	P	G	G	G	VG	F	G
Straw		G	G	F	F	F	VG	F	G
Wood Chip		-	-	F	G	F	F	F	G
Saw Dust		G	P	F	P	F	F	F	G
Aquatain 1/		G	G	F	P	F	F	F	G
None		G	P	F	P	F	F	F	G
Stone	3:1	G	G	G	G	G	F	VG	VG
Straw		G	P	G	G	G	F	G	G
Wood Chip		G	P	G	G	G	G	G	G
Saw Dust		-	-	G	F	G	F	G	G
Aquatain 1/		G	VG	G	G	G	F	G	G
None		G	G	G	F	G	FG	G	G
								2,3	2
Stone	4:1	G	G	G	VG	G	VG	F	F
Straw		G	P	F	G	G	F	FG	F
Wood Chip		G	F	F	G	G	FG	F	F
Saw Dust		G	P	F	G	G	F	F	F
Aquatain 1/		FG	F	F	F	G	F	F	F
None		F	P	F	P	G	F	F	F

P = Poor
F = Fair
G = Good
VG = Very Good
EC = Erosion Control

1. Original application to light - second opp. necessary
2. 2:1 and 4:1 plots low in fertility especially in May 1975
3. Erosion at toe of slope not necessarily related to mulch material

Table 2. Wertz Drain, South of Notestine Road

Mulch	Slope	5-14-74		5-28-74		5-2-75	
		E.C.	Cover	E.C.	Cover	E.C.	Cover
Stone	2:1	G	none	G	F	VG	VG
Straw	2:1	G	none	G	G	VG	VG
Wood Chip	2:1	G	none	G	G	VG	VG
None	2:1	G	none	G	F	G	G
Stone	3:1	G	none	G	F	VG	G
Straw	3:1	G	none	G	G	VG	G
Wood Chip	3:1	G	none	G	F	FG	FG
None	3:1	G	none	G	F	G	F
Stone	4:1	G	none	G	P	VG	VG
Straw	4:1	G	none	G	G	VG	VG
Wood Chip	4:1	G	none	G	P	VG	VG
None	4:1	G	none	G	P	VG	VG

P = Poor
F = Fair
G = Good
VG = Very Good
EC = Erosion Control

[a] All but stone mulch washed away in high water first week of May 1974. Sediment up to 2" thick deposited in 4:1 slope plots during this high water. Less sediment in 3:1 and 2:1 plots.

stone mulch had slightly better resistance. For the soil conditions existing in these two sites, a 2:1 or 3:1 slope would be adequate. It is necessary, however, that the channel bottom be stable.

Structural Measures to Control Channel Erosion

Three structural measures installed in the Black Creek Watershed deserve particular attention as devices for reducing stream channel and bank erosion. Other techniques such as grass border strips along the banks and drop inlet pipes are important contributors to erosion control but will not be discussed here. The techniques of design of the three structural measures will not be covered but only a general description of the operation of the structure.

The rock drop structures consist of armoring in the channel with rip-rap. A short inlet section, approximately 40 feet, is provided. In the next 20 feet, a two foot fall occurs. This is followed by a section of approximately 40 feet to provide the necessary energy dissipation. Several of these structures have been installed to reduce channel gradients, the first of these in 1973. They have gone through several periods of full ditch fall with no difficulties. Grass is now becoming established in the earlier structures and there appears to be no question of their stability.

A second type of structure, a sheet piling weir, was initially installed as a channel stabilization device for the monitoring stations. This consists of steel pilings driven into the channel and then cut to approximately the original channel cross section. Since they were not installed as grade control devices, only about a six inch overfall was provided although one does have over a one foot overfall.

It was found to be necessary to provide some stone immediately above the piling, about two feet, and to provide stone for controlling erosion immediately below the overfall even though they were very small. During periods of low flow the stone below the weir hindered the migration of the small fish up to the overfall. It is not known how much stone would be needed for larger overfalls.

It appears likely that the piling could be used in conjunction with the rock structure previously discussed, perhaps instead of the inlet section. Also a small pool suitably reinforced with large rock could be allowed to develop below the over fall. This structure takes less channel length than the rock drop and might be practical where rip-rap is scarce or high priced.

A third structural measure consisted of armoring the toe of the slope with small rock about 2-1/2 to 3" size. It has been referred to as streambank training. This method was used in a reach of the channel where the lower bank had low erosion resistance and the stream had started to meander badly. The installation was made in 1974. To date it has withstood the bank full runoff of the May 20, 1975 storm plus several other major flows. It is working successfully. Grass has now grown through the rocks so that it is no longer visible and should add additional stability. As long as the channel bottom is not subject to degradation, there is no question to what this test site will be successful in protecting the streambank.

Survey of Streambank Erosion

As a part of the International Joint Commission PLUARG studies, streambank erosion is being surveyed under the direction of a Mr. W. F. Mildner of the of the Soil Conservation Service. These studies are generally made on a statistical sampling basis, but because of the intensity of the Black Creek Study and the size of the basin, a complete survey was made in this particular watershed.

The study was conducted in the summer of 1975 and the data has recently been made available to the author by Mr. Mildner. The survey covered 29.3 miles on stream for a total bank miles of 58.6. The following measurements are listed in bank miles. The drainage density was determined to be 1.56 miles of channel per square mile. It was determined that there are 7.2 eroding bank miles producing approximately 400 tons of sediment per year. It was estimated that only 6.3 miles of simple treatment and 0.9 miles of armoring would solve this problem. At the present time there are 18.4 miles of simple treatment and 1.7 miles of armoring in the watershed.

There does not appear to be any correlation of the bank erosion with use of the adjacent land or with whether or not the banks are fenced. It is interesting to note that over 80% of the total tons of streambank erosion are produced by two soil types, Eel 59.4% and Shoals 25.1%. Yet the same soils account for only 18.7 and 7.3% respectively of the total miles of streambanks.

While this survey shows a relatively small amount of sediment produced by streambank erosion, nevertheless at the site of occurrence the erosion may be quite severe. Often the eroding sections can be controlled with a comparitively small amount of simple treatment. The need to control bank erosion emphasizes a need for a good maintenance program in any plan to reduce sedimentation.

SEDIMENT TRAP FOR MEASURING BED LOAD MOVEMENT IN BLACK CREEK

by

R. E. Land[1] and R. Z. Wheaton, Ph.D.[2]

ABSTRACT

There is a real need for a method of determining the quantity of bed load movement in streams on alluvial soils. On this thought, the agencies involved in the Black Creek Sediment Control Project, Allen County, Indiana, agreed to set-up an investigative study using a flow-through type sedimentation basin to search for such method. The basin was designed and built in September, 1974. The study is continuing at this date. Some data has been collected. However the study has not progressed to a point where a prediction can be made. It is hopeful that the study can be carried out to the point where bed load movement in streams can be determined and directly related to field runoff events.

BACKGROUND

It was the decision of all agencies involved in the Black Creek Sediment Control Project (E.P.A., A.C.S.W.C.D., S.C.S. and Purdue University) to set up an investigative study on a flow-through type sedimentation basin in an effort to determine the effectiveness of such sediment traps in upstream channels of small watersheds. Personnel of the Soil Conservation Service were particularly interested in the investigation since the agency was lacking in any data pertaining to such sediment basins.

It was agreed that the basin would be installed in the main stream of Black Creek - below the entrance of its main tributaries and above the back-water effects of the Maumee River. The basin would be constructed by widening and deepening the existing channel - thereby decreasing the velocity of the stream and creating plain sedimentation.

A site was finally located with a straight section of channel of sufficient length to install the basin, and permission was granted by

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the landowner to construct. The site did not entirely satisfy the guidelines since on occasion the area was affected by backwater from the Maumee River, however, the backwater normally occurred after runoff events in Black Creek and it was felt that the occurance would have little affect on the investigation.

The channel at the selected site had the following average measurements: d = 12 ft., b = 10 ft., ss = 2:1.

DESIGN

The basin was designed with two primary objectives in mind: (1) to trap particles of high specific gravity and (2) to gain knowledge of the bed-load movement in the channel.

Design procedure and calculations were submitted by the Soil Conservation Service. Procedure used was that generally used in the design of sedimentation tanks as related to water treatment.

where $$v = \frac{Q}{A} \qquad (1)$$

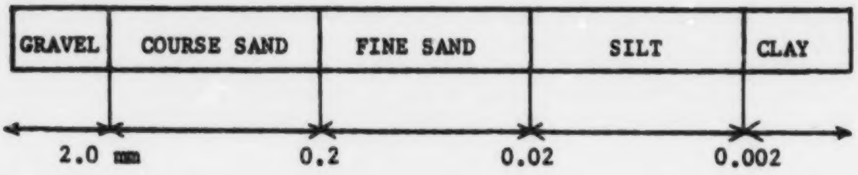
v = settling velocity of the smallest soil partical to be removed

Q = outflow

A = surface area of the basin (bottom)

A "v" value of 0.0625 ft/sec settling velocity of a partical 0.074 mm in diameter with a 2.65 specific gravity was selected from a paper by William W. Rubey on "Settling Velocities of Gravel, Sand, and Silt Particals." From the Atterburg system of partical size separation, fig. 1, it can be seen that particals of 0.074 mm fall in the fine sand range.

Fig. 1. Atterburg System of Partical Size Separation



An outflow of 500 cfs was assumed - based on experience of previous runoff calculations from watersheds of like area, slope and cover.

With these values "A" becomes 8,000 sq. ft.

Development of the above formula reveals that "d" cancells out, therefore depth is not a factor, but "d" must not be so shallow that bed velocity becomes high for obvious reasons. Also the shape of the basin is not a factor as long as the horizontal velocity is not so great as to prevent, by turbulance, the settling of particals under gravity. With these requirements in mind the following basin dimensions were established:

L = 400 ft.

b = 20 ft.

d = 4 ft. below the existing channel bottom giving a designed flow depth of 10 ft.

ss = 3:1 below the existing channel bottom

ss = 2:1 above the existing channel bottom

Tapered inlet and outlet sections of 70 ft. in length

Contract for construction was let in August 1974, and work was completed the following month. The basin was built as designed except that the side slopes were changed from a two plain 3:1 and 2:1 to a one plain 2.35:1 to facilitate construction.

From the basin design dimension we get a detention time of 3.0 minutes and a horizontal velocity of 2.2 ft./sec. The horizontal velocity would be a minimum since no allowance was made for sediment storage in the calculation.

We note that the horizontal velocity is higher than the generally accepted maximum horizontal velocity of 1 ft/sec for settling of sand in the design of grit chambers and much too high for the settling of particals of light specific gravity. However from the basin design values, theoretically, we can expect to settle out all particals of specific gravity 2.65 and a falling rate of 0.0625 ft/sec, and since particals of less falling velocity than $\frac{Q}{A}$ will be removed in the same proportion as their velocity bears to $\frac{Q}{A}$ we can expect to trap, 50% of those particals having a falling velocity of 0.0312 ft/sec and so on.

DATA COLLECTED AND DISCUSSED

A survey of the basin was made on July 30, 1975, to determine the amount of sediment accumulated from events of the previous eleven months. Cross sections were made at three sections in the first 100 ft. of basin where needed, and every 50 ft. through the remaining section of the basin. Cross sections of the survey are shown in fig. 2 and 3. As would be expected, most of the sediment drop out is in the first portion of the basin, also the sections indicate a meandering of the stream flow. Results of the survey show that 980 cu. yds. of sediment had been collected.

As a point of interest, records from water sampling stations up stream from the basin indicate approximately 10,000 cu. yds. of suspended sediment had entered the basin during the same eleven month period mentioned above, however it must be noted that this is suspended sediment and would not be an indication of the efficiency of the basin as designed.

Soil samples of the accumulated basin sediment was taken after the survey. Partical size analysis is shown in table 1.

Figure 2. Cross Sectional View of Deposition in Constructed Desilting Basin

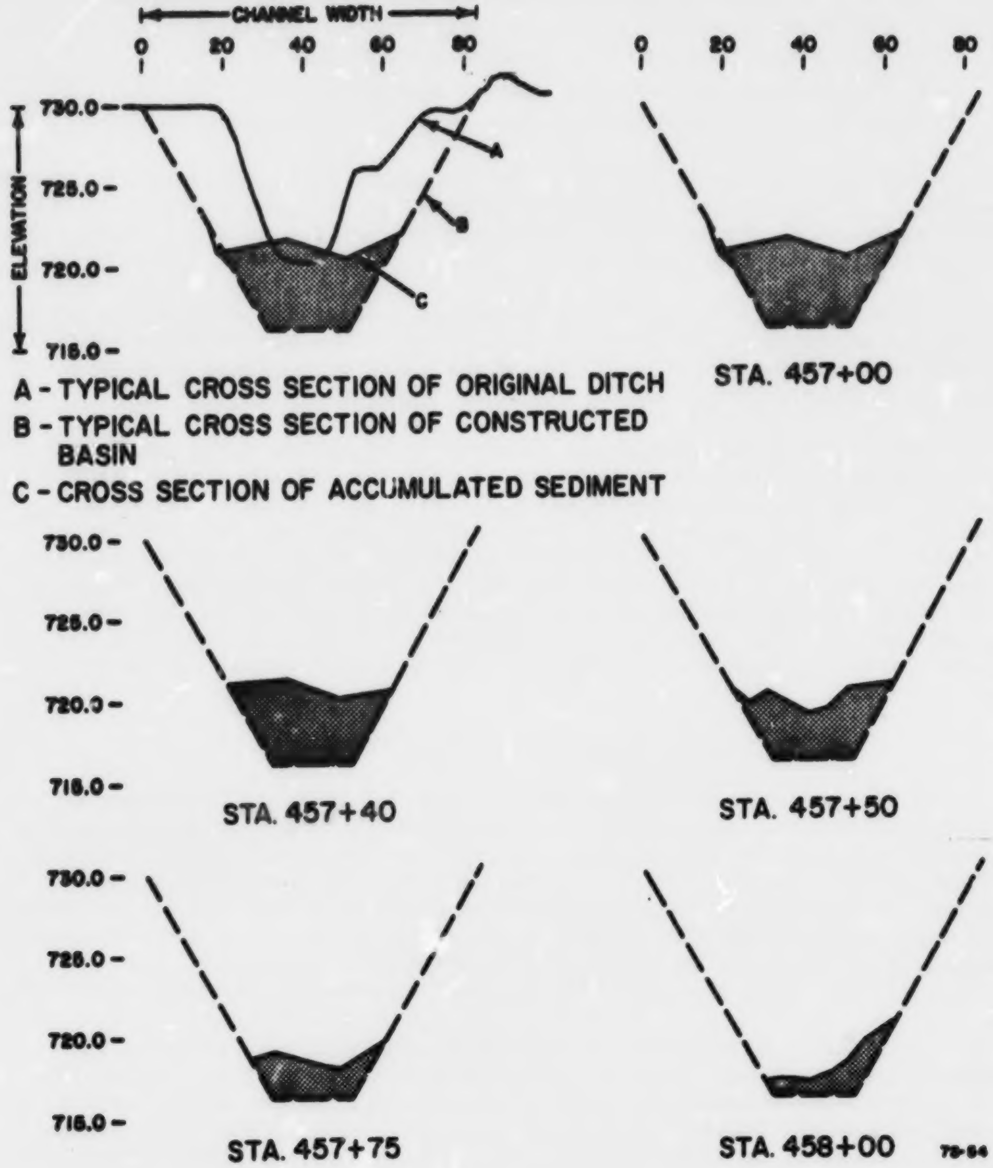


Figure 3. Cross Sectional View of Deposition in Constructed Desilting Basin (con't)

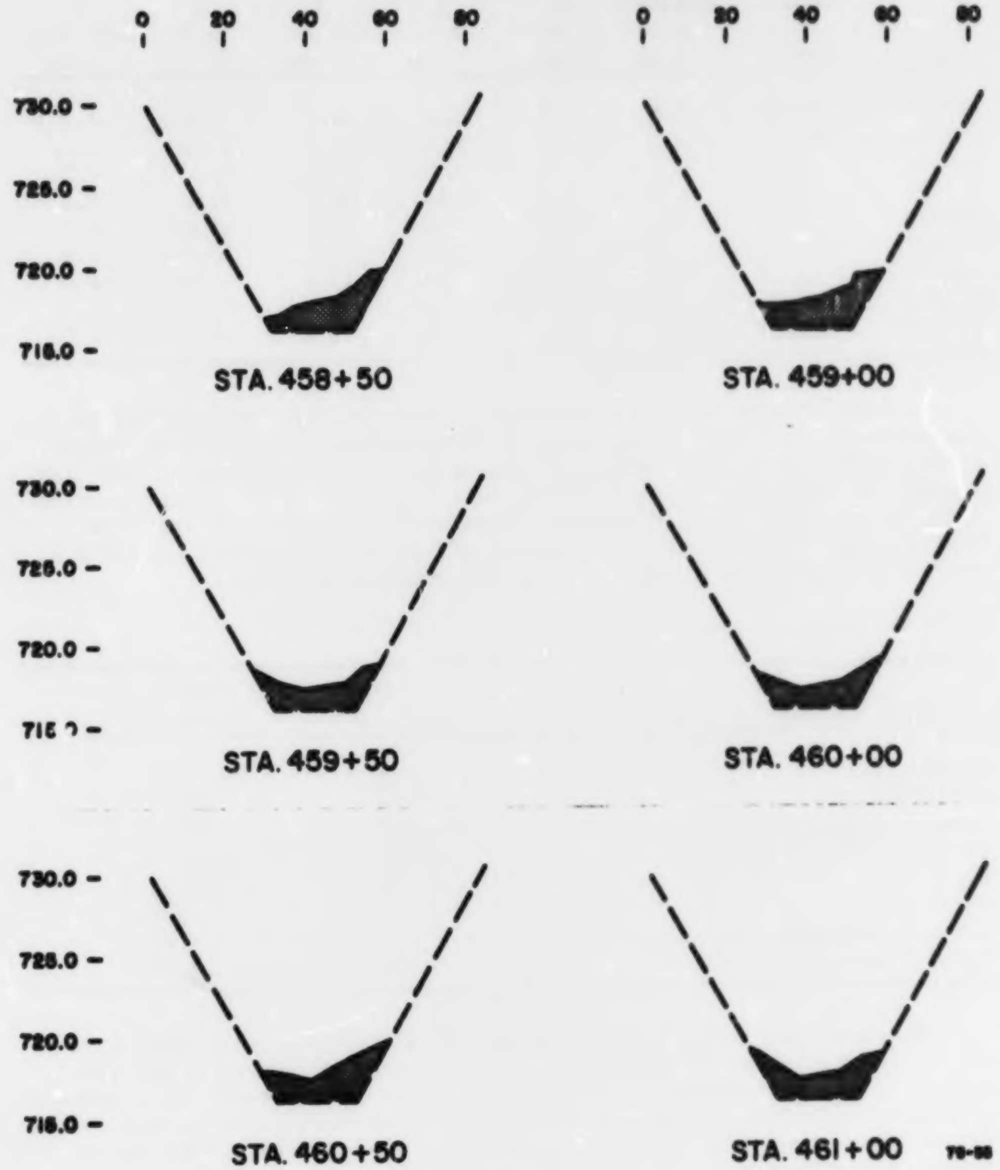


Table 1. Partical Size Analysis

Sta	Total % Sand	% Greater than 2 mm	% 1 to 2 mm	% .5 to 1 mm	% .25 to .5 mm	% .1 to .25 mm	% .05 to 1 mm
457+00	87.2	18.6	7.8	21.0	29.0	8.5	2.3
457+50	84.2	9.3	5.7	16.3	31.2	16.1	5.5
458+00	77.8	3.1	1.4	3.4	28.8	32.0	9.1
458+50	75.2	2.9	1.2	4.6	38.9	18.9	8.8
459+00	72.6	4.6	1.4	4.8	33.1	20.5	8.2
459+50	60.5	.5	.3	1.9	23.1	23.6	11.2
460+00	48.7	.5	.2	.8	13.5	21.4	12.5
460+50	38.2	.4	.3	.5	5.0	18.7	13.4
461+00	29.9	.0	.1	.3	2.4	14.2	12.9

As can be seen from the analysis, particals with the highest settling velocity fall out at the head of the basin and decreased in volume as stationing progressed down stream. A factor of interest is the high percent of particals accumulated of less than 0.05 mm in diameter or in the silt and clay classification. Results of a water sampling (grab sample) taken at the inlet and outlet of the basin is given in table 2, which also indicates a degree of light sediment fall out.

Table 2. Water Sample Analysis

Sample Description	Basin Inlet	Basin Outlet
Solids mg/L	412.0	360.8
Soluble P ppm	286	235
Total P filtered ppm	331	280
Total P unfiltered ppm	1044	1010
NH_4 + ppm	31	31
NO_3 - ppm	3.09	3.09
Total N filtered ppm	4.72	4.25
Total N unfiltered ppm	12.01	8.65

Since we are continuing to collect data, we can not at this time make a prediction as to the study. We are aware of the problems presented by not being able to control the inflow to the basin or to create a uniform velocity through the basin. It is known that on several occasions the actual flow has far exceeded the design flow - this may have caused a flushing action. From the amount of sediment trapped and from observation of the sand bars down stream from the basin, it is known that the bed load movement in Black Creek is considerable.

GRASSED WATERWAY DESIGN

by

Claudius F. Poland*

Grassed waterways and outlets are natural or constructed waterways shaped to required dimensions and vegetated for safe disposal of runoff from a field, diversion, terrace or other structures.

The grass-lined waterway is used when rainfall exceeds the rate or volume at which the soil can take in and store moisture. Surplus water will pass over the land in the form of runoff. Since the success of any soil conservation program depends on the removal of this surplus water without undue erosion, the area needed for waterways should be dedicated to this purpose.

The satisfactory performance of a vegetated waterway depends on it having the proper shape, as well as the preparation of the area in a manner to provide conditions favorable to vegetative growth. Between the time of seeding the cover and the actual establishment, a waterway is unprotected and subject to considerable damage unless special protection is provided. Waterways subject to constant or prolonged flows require special supplemental treatment, such as grade control structures, stone centers, or subsurface drainage capable of carrying such flows. After establishment, protective vegetative cover must be maintained.

Vegetative outlets and waterways are used for the following purposes:

1. As outlets for diversions and terraces,
2. To dispose of water collected by road ditches or discharged through culverts,
3. To rehabilitate natural draws carrying concentrations of runoff.

The waterway may be protected by using a combination of the following steps that best fit the needs of the site.

1. Construct the waterway in advance of any other channels that will discharge it.

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2. Establish the vegetative cover according to recommended techniques.
    a. Protect the channel seeding with mulch (manure, stubble, straw, jute netting, or wired and staked mulch).
    b. Sod the channel.
    c. Irrigate the new seeding or sodding to insure and hasten establishment if needed.

3. Carry prolonged flow in a subsurface drainage system.

4. Use stable natural waterways where possible.

5. Maintain vegetative cover by mowing, fertilizing, and performing other maintenance work as needed.

Vegetative waterways may be built to three general shapes or cross sections -- parabolic, trapezoidal, or "V" shaped. Parabolic waterways are the most common and generally are the most satisfactory. It is the shape ordinarily found in nature. Small flows are less likely to meander. The cross section should be designed to permit easy crossing of equipment where necessary.

The most satisfactory location for a waterway is in a well-vegetated natural draw. These locations should be used where possible since they have one or more of the following advantages:

1. Flattest grade in the immediate area,

2. Most stable channel conditions,

3. Adequate capacity,

4. Soil and moisture conditions most favorable to vegetative growth,

5. Sufficient depth for outletting diversions, terraces, and rows at grade.

Surveys

The total drainage area and subwatershed divides can be determined by field inspection or by the use of a stereoscope on an aerial photograph, and sketched on the photograph for measurement. U.S.G.S. maps may be used to determine drainage areas.

The original ground surface should be profiled and cross sectioned in enough detail to permit dividing the waterway into reaches of approximately uniform slope and shape.

Design

The design of a waterway is the determination of a channel dimension that will carry the estimated flow without damage to the channel or its lining. Vegetative linings vary in their protective ability according to type and density. Therefore, safe velocities under various conditions are a matter for careful consideration.

Design Storm Frequency

Waterways are constructed to discharge the peak flow expected from a storm of at least a ten-year frequency. Out-of-bank flow may be permitted on land slopes parallel to the channel where the slope is not greater than one percent and it is evident that no erosion damage or serious crop damage will result.

Vegetative Retardance Factor

The design of a vegetated waterway is more complicated than for a bare channel, since the value for "N" (Mannings coefficient of roughness) varies where grass linings are used. Vegetation tends to bend and oscillate under the influence of velocity and depth of flow. Thus, the retardance to flow varies as these factors change.

Large and small channels of different cross-sectional shape and bed shape, and with different vegetal covers, the retardance coefficient "N" varies with VR. The term VR is the product of velocity and the hydraulic radius. This relationship will be referred to as the "N-VR relationship", which is recommended as the basis for vegetated channel design.

Design Data

The following information is required for designing a waterway:

1. Watershed area in acres, together with the soil characteristics, cover and topography. This information is used to estimate runoff.
2. Grade of the proposed waterway in percent slope (this is the fall in feet per 100 feet of length).
3. Vegetated cover adapted to site conditions.
4. Erodibility of the soil in the waterway.
5. Expected height at which vegetative cover will be maintained.
6. The permissible velocity for the conditions encountered.
7. Allowance for space that will be occupied by the vegetative lining.

Design Procedures

Waterways are frequently planned where the slope is variable and where there is a wide difference in the watershed area at various points along the channel. In such cases, the waterway is designed in reaches.

A reach is usually a portion of the watershed having a near-uniform slope and drainage area. A point of significant break in slope is a point of division between two reaches. The point of entrance of a tributary where the watershed is significantly increased also may be a point of division between two reaches. When the limits of two or more reaches have been determined, each reach is designed separately.

Drainage of Waterways

Vegetated waterways, to be effective, must not be subjected to low flows of long duration or kept wet for long periods. A tile system providing drainage and protecting the center of the waterway should be considered where prolonged low flows or wet conditions prevail.

Tile lines should be parallel to the center of the vegetated waterway but be offset from the centerline at least one-fourth the top width of the waterway. Two lines may be required in some cases, one each side of the center. The tile line(s) may be outletted through a drop structure at the end of the waterway if there is a significant difference in elevation between the tile and channel outlets, or through a standard tile outlet.

The following is an example of design of a sod waterway in Black Creek Watershed:

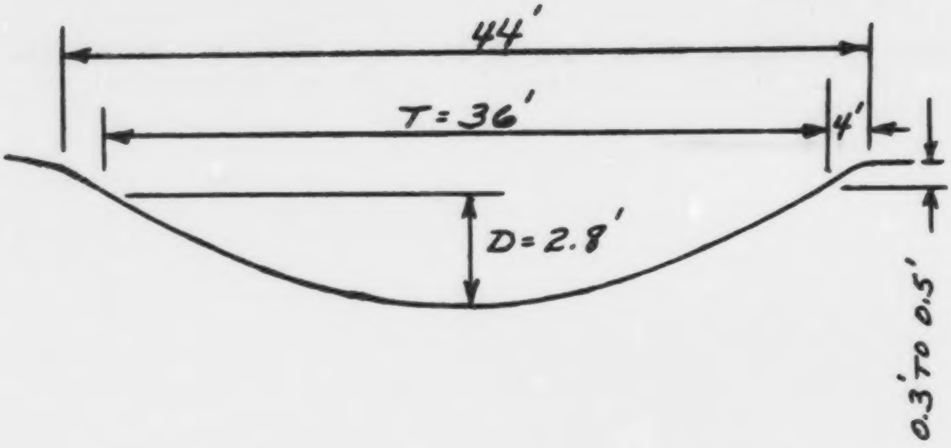
Given: 482 acres drainage area
Watershed topography 0 to 3%
Watershed cover 20% cultivated
30% small grain
40% hay and pasture
10% woods, farmsteads, and roads
Grade - 0.3%
Vegetative cover (after establishment) - tall fescue
Condition of vegetation:
Good stand - mowed (4" to 6")
Good stand - headed (6" to 18")
Soil - moderately erodible
Permissible velocity - 4.0 f.p.s.

Find Q: When Q is found from 10 year storm of 24 hour duration in Black Creek Watershed, Allen Co., Indiana.

From TP 40 - Q_{10} 24 hr. = 3.87" rainfall
From Chapter 2 of S.C.S. Engineering Field Manual
$Q = 210$ c.f.s.
From Chapter 7 of S.C.S. Engineering Field Manual
Exhibit 7-5 (0.25 percent slope) $V_1 = 4.0$; $T = 20.4'$;
$D = 3.9'$; $V_2 = 3.9$ f.p.s.

Note: The sod waterway would be deep and narrow, therefore, the waterway would be difficult to cross. The dimensions were changed as follows: $V_1 = 3.0$; $T = 36'$; $D = 2.8'$; $V_2 = 3.0$ f.p.s.

The above dimensions include growth of vegetation. The drawing shows 4' each side of waterway and 0.3' to 0.5' depth for freeboard. They are sometimes added to the design for safety, which has been done for waterways that have large drainage areas in Black Creek Watershed.



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NUTRIENT CONTRIBUTIONS TO THE MAUMEE RIVER

by

L. E. Sommers, D. W. Nelson, and D. B. Kaminsky, Jr.*

ABSTRACT

The nutrient content of surface runoff, tile drain effluents and surface waters in the Black Creek watershed was evaluated. Rainulator studies indicated that an average of 3.5 and 3.8% of N and P, respectively, was lost in surface runoff after surface application of fertilizer. A study of tile effluents indicated that concentrations of N and P present were comparable to or greater than those found in surface waters. Based on average concentrations, tile effluents and surface runoff are equally important as sources of nutrients entering surface waters in the watershed. Routine analysis of surface water samples within the watershed indicates that the median concentrations of N are higher than those found in the Maumee River while the reverse trend was observed for P.

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The nutrients of primary concern in eutrophication are N and P. Because of the capacity of many blue-green algae, a major component of the microflora in eutrophic waters, to fix atmospheric N_2 whenever the "available" N status of waters becomes depleted, much emphasis has been placed on the factors controlling the forms and amounts of P entering streams, lakes, etc. This rationale was instrumental in implementing bans on phosphate detergents in some states, including Indiana. Such actions will influence P entering natural waters from point-sources (e.g., sewage treatment plants). Of equal significance to point-sources are non-point sources of nutrients, including agricultural land.

The two major sources of nutrients entering natural waters from agricultural land include surface runoff and subsurface drainage (ground water and tile drain effluent). Obviously, nutrient losses via these routes will be influenced by factors such as land use, fertilizer usage, management practices, climate, topography, soil type, etc. Furthermore, the ultimate form of a particular nutrient, i.e., N or P, entering a body of water will be controlled by physical, chemical and biological processes occuring during removal from the land and transport through drainage ditches, streams, etc. The objectives of this paper will be (1) to present data on the forms and amounts of N and P in surface runoff, tile drain effluents and surface waters of the Black Creek watershed and (2) to evaluate the realtionships between various nutrients in water samples.

MATERIALS AND METHODS

Evaluation of Nutrient Losses in Surface Runoff

The rainfall simulator described by Meyer and Mannering (1) was used to evaluate the loss of fertilizer and native soil N and P from four soil types found in the Black Creek watershed. The characteristics of the four soils studied are as follows: Haskins loam - 0.1 to 0.3% slope, 12.5% clay, 44.5% silt, 1021 ppm total N, and 363 ppm total P; Nappanee clay loam - 0.7 to 0.8% slope, 29.5% clay, 41.5% silt, 1557 ppm total N and 706 ppm total P; Morley clay loam - 4.7 to 5.2% slope, 33% clay, 43.5% silt, 1240 ppm total N and 366 ppm total P; Hoytville silty clay - 0.3 to 0.7% slope, 43.8% clay, 42% silt, 2969 ppm total N and 3164 ppm total P. All plots were disked once at right angles to the slope and once up and down slope. Two plots of each soil type were fertilized with 56 kg P/ha of triple superphosphate and 168 kg N/ha as NH_4NO_3. Rainstorms were applied at an intensity of 6.35 cm/hr. Two rainstorms were applied to the plots, one of sixty minute duration and one of thirty minute duration.

Monitoring of Tile Drain Effluents

Water samples were obtained from 283 tile outfalls during the period

May 13 to June 7, 1974. An estimate of flow was obtained at the time of water sample collection but it should be noted that tile flows were during the declining phase of the hydrograph.

Water quality parameters in the tile effluents were determined by the following procedures: suspended solids by filtering a sample through a 0.45 μ filter, drying, and weighing the dried filter; total P (2), total N (3), NH_4^+ and NO_3^- (4). Both filtered (0.45 μ) and unfiltered samples were analyzed for chemical constituents. Soluble inorganic P was determined in filtered samples (5). All water samples were preserved by freezing.

Monitoring of Stream Water

Grab samples were obtained from 13 sites in the Black Creek watershed and from one site on the Maumee River (Fig. 1). The results represent analysis of approximately 150 samples collected from each of the 14 sampling sites during the 19 March, 1973 to 29 December, 1974 time period. Automatic pump samplers (PS-69) were employed at 3 sites (Nos. 2, 6 and 12) to follow changes in water quality during storm events. All water samples were preserved and analyzed as described above.

RESULTS AND DISCUSSION

Evaluation of Nutrient Loss in Surface Runoff

As determined by rainulator studies, the losses of soil and nutrients were low from these gently sloping soils (Table 1). In view of the experimental conditions employed (i.e., N and P fertilizer were applied to the soil surface just prior to application of a 6.5 cm/hr rainstorm), the nutrient losses obtained should be regarded as maximum values for the soils studied. Soil losses from rainstorms applied ranged from 0.15 to 2.18 tons/acre for the Nappanee clay loam (~1% slope) and Morley clay loam (~5% slope). Previous research (6) has shown that soil losses of 21.4 and 24.7 tons/ha resulted from two successive rainstorms applied to a conventionally tilled Bedford silt loam (8.3 to 12.4% slope). Due to the low percent slope possessed by the majority of soils in the Black Creek study area, it is likely that the total amount of runoff and soil erosion occurring on these soils will be low when compared to the bulk of data collected during soil erosion research.

It is evident from looking at the data that fertilizer application resulted in increased nutrient loss from soils (Table 1). The increases are the greatest in the soluble ammonium, nitrate and inorganic P fractions. Sediment P also appears to increase with fertilizer addition probably as a result of sorption of added inorganic P by the clay fraction in soil. The loss of sediment N does not seem to be markedly affected by fertilization.

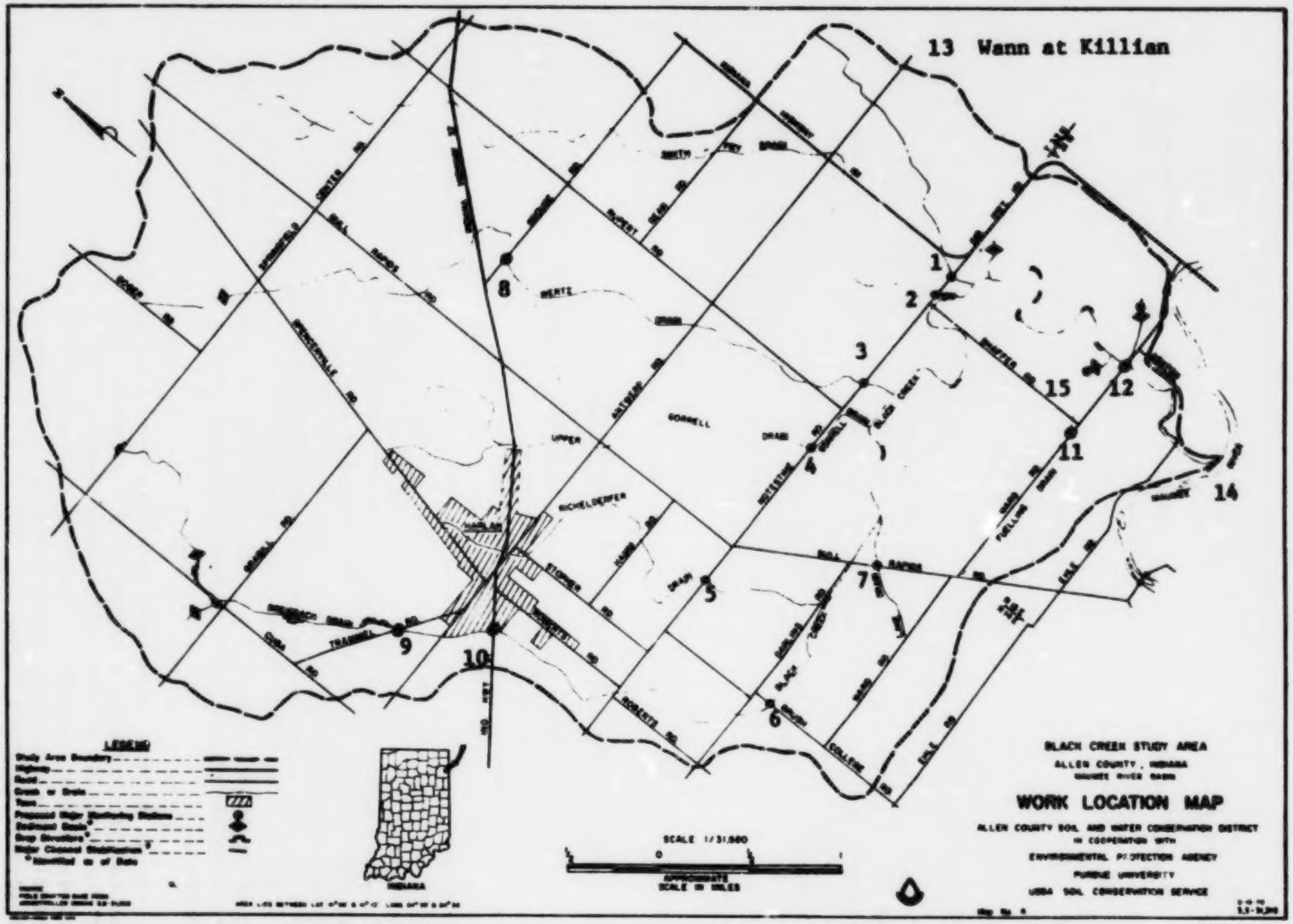

Fig. 1. Location of routine water quality monitoring sites in the Black Creek study area.

Table 1. Losses of soil and fertilizer N and P in surface runoff from fertilized and non-fertilized plots of four soil types

Rainstorm No.[a]	Treatment[b]	Runoff		N in runoff as				P in runoff as		
		Total	Solids	NH_4^+-N	NO_3^--N	Sed. N	Sum	Soluble Inorg. P	Sed. P	Sum
		tons/ha		kg/ha x 10^{-1}						
						Haskins loam				
1	U	305	2.28	0.67	7.06	52.70	61.31	0.19	24.10	24.46
	F	368	2.05	0.51	5.47	54.20	67.47	3.02	29.10	33.37
2	U	239	1.24	0.91	0.91	30.26	35.39	0.21	10.60	10.93
	F	264	1.17	5.47	2.58	32.00	42.06	1.15	12.00	13.23
						Nappanee clay loam				
1	U	168	0.32	0.30	1.98	17.00	20.20	0.13	3.80	3.06
	F	210	0.42	8.63	2.95	41.30	56.40	1.40	8.84	10.39
2	U	195	0.29	0.23	0.74	13.10	15.38	0.12	3.79	4.02
	F	251	0.77	8.10	7.32	36.70	52.12	0.51	9.31	9.95
						Hoytville silty clay				
1	U	253	0.41	0.54	17.08	38.50	56.12	0.54	8.22	9.06
	F	233	0.78	8.63	30.27	27.80	77.18	2.06	15.94	18.20
2	U	256	0.68	0.23	3.40	39.50	43.46	0.49	13.78	14.38
	F	283	0.88	8.10	5.46	54.30	75.96	0.88	19.91	20.89
						Morley clay loam				
1	U	395	3.94	1.07	3.67	200.90	205.88	0.04	27.13	27.29
	F	389	4.38	16.29	7.77	242.22	266.26	1.15	59.05	60.40
2	U	280	3.19	0.66	3.48	113.37	117.84	0.03	22.08	22.16
	F	289	3.70	14.07	7.25	133.20	157.18	0.56	33.37	33.94

[a] Rainstorms 1 and 2 were for 60 and 30 min. respectively.

[b] U, unfertilized plots; F, fertilized plots.

The percent of the various types of N and P found in the runoff as compared to the total amounts of N and P in runoff is listed in Table 2. In unfertilized plots the large majority of the N found in runoff is in the sediment. On the contrary, with fertilized plots the proportion of sediment N in runoff decreased as the NH_4^+-N and NO_3^--N originating from fertilizer increased. However, the fraction of sediment N in runoff from fertilized plots was at least 41% and in most cases greater than 50% of the total N. In unfertilized plots, almost all the P in runoff was sediment P. When plots are fertilized the percentage of total P in runoff present as sediment P decreases but stays at relatively high levels. Data from the fertilized plots reveals that at least 85% of the total P in runoff was in the sediment phase. From the above data it can be concluded that the most effective way to control loss of P and, to a lesser extent, N is to control soil erosion. Substantial decreases in the total nutrient load would have occurred if soil erosion were decreased. Most likely the amounts of soluble N and P in runoff would decrease if the fertilizer were incorporated in a way that would also minimize erosion.

The majority of soluble inorganic N and P in runoff is derived from fertilizer (Table 3). In most cases the majority of sediment N is derived from the soil. The Nappanee clay loam was an exception since the sediment N derived from fertilizer sources was quite high. This finding may be due to the high clay content of the soil which would increase the probability of large amounts of added NH_4^+ present on the exchange sites of the eroded soil. A substantial proportion of the sediment P appears to be derived from the added fertilizer. This finding is further substantiated by the increased concentration of P in the sediment from fertilized plots as compared to the level in sediment from unfertilized plots. The increases in sediment P and N in runoff resulting from fertilizer are apparently due to the attachment of ammonium to cation exchange sites and the soprtion of phosphate by the clay mineral surfaces shortly after fertilization. These nutrients are then carried from the plots as components of the sediment during erosion.

Total inorganic N removed in runoff from the two storms varied from 0.4 to 2.2% of the fertilizer N applied (Table 4). Losses of fertilizer N from the Haskins soil were substantially lower than from the other three soils. The elevated sand and lower clay content of the Haskins soil may have allowed increased infiltration. Thus, ammonium and nitrate were leached into the soil profile, reducing their susceptibility to runoff. The total amount of fertilizer N lost in all forms varied from 0.8% to 5.9% of that added (Table 4). The losses of added N from the Haskins soil again were much lower than the other soils which seems to indicate the clay content of the soil may be the difference since the fertilizer N lost in the sediment phase was probably in the form of ammonium on the cation exchange sites.

The percentages of soluble inorganic P removed by runoff water varied from 0.3%-0.7% of that added and the amount of added P lost in all forms varied from 2.0-8.0% (Table 4). The losses of fertilizer P were larger than

Table 2. Percentage distribution of the total amounts of N and P in surface runoff among the N and P components in runoff from fertilized (F) and unfertilized (U) plots of four soil types.

Rainstorm No.	Storm duration	Treatment	% of total N in runoff as: NH_4^+-N	NO_3^--N	Sol. Org. N	Sed. N	% of total P in runoff as: Sol. Inorg. P	Sol. Org. P	Sed. P
	min.				Haskins loam				
1	60	U	1.1	11.5	1.4	86.0	0.8	0.7	98.5
	60	F	7.6	8.1	4.0	80.3	9.1	3.8	87.2
2	30	U	2.6	4.9	7.0	85.5	1.9	1.1	97.2
	30	F	13.0	6.1	4.6	76.1	8.7	0.6	90.7
					Nappanee clay loam				
1	60	U	1.5	9.8	4.5	84.2	3.2	0.8	96.0
	60	F	15.3	5.2	6.3	73.2	13.5	1.4	85.1
2	30	U	1.5	4.8	8.5	94.9	3.0	2.7	94.3
	30	F	15.5	14.0	0.0	70.4	5.1	1.3	93.6
					Hoytville silty clay				
1	60	U	1.0	30.4	0.0	68.6	6.0	3.3	90.7
	60	F	11.2	39.2	0.6	49.0	11.3	1.1	87.6
2	30	U	0.5	7.8	0.8	90.9	3.6	0.8	95.8
	30	F	10.7	7.2	0.0	71.5	4.2	0.5	95.3
					Morley clay loam				
1	60	U	0.5	1.8	0.1	97.6	0.1	0.4	99.4
	60	F	6.1	2.9	0.0	91.0	1.9	0.3	97.8
2	30	U	0.6	3.0	0.0	96.5	0.1	0.2	99.6
	30	F	9.0	4.6	1.7	84.7	1.6	0.0	98.3

Table 3. Percentage of plant nutrients in runoff water and sediment from fertilized soil derived from fertilizer.[a]

Soil type	Rainstorm No.	Form of N in runoff			Form of P in runoff		
		Sol. Inorg. N	Sed. N	Σ of all N forms	Sol. Inorg. P	Sed. P	Σ of all P forms
		% of N derived from fertilizer			% of P derived from fertilizer		
Haskins loam	1	26.9	2.8	9.1	93.7	17.2	26.7
	2	67.1	5.4	15.8	81.7	11.7	17.4
Nappanee clay loam	1	80.3	58.8	64.2	90.7	57.0	61.9
	2	93.7	64.3	70.5	76.5	59.3	59.6
Hoytville silty loam	1	54.7	0.0	27.3	73.8	48.5	50.2
	2	73.2	27.3	42.8	44.3	30.3	31.2
Morley clay loam	1	80.3	17.1	22.7	96.5	54.1	54.8
	2	80.7	14.7	25.0	94.6	33.8	34.7

[a] Calculated by subtracting the nutrient loss from the untreated plot from that of the fertilized plot, dividing the difference by the nutrient loss from the fertilized plot, and multiplying the resultant value by 100.

Table 4 Amount of added fertilizer nitrogen and phosphorus lost in runoff from four soil types.[a]

Soil type	Rainstorm No.	Added N lost in runoff as:		Added P lost in runoff as:	
		Sol. inorg. N	All N forms	Sol. inorg. P	All P forms
		--------% of added N--------		---------% of added P---------	
Haskins loam	1	0.2	0.4	0.5	1.6
	2	0.2	0.4	0.2	0.4
		0.4	0.8	0.7	2.0
Nappanee clay loam	1	0.6	2.1	0.2	1.1
	2	0.9	2.1	0.1	1.1
		1.5	4.2	0.3	2.2
Hoytville silty clay	1	1.3	1.3	0.3	1.6
	2	0.6	1.9	0.1	1.2
		1.9	3.2	0.4	2.8
Morley clay loam	1	1.2	3.6	0.2	5.9
	2	1.0	2.3	0.1	2.1
		2.2	5.9	0.3	8.0

[a] Percent of added nutrients lost in runoff was calculated by subtracting the nutrient loss from untreated plots from that of the fertilized plot, dividing the difference by the amount of nutrient added, and multiplying the resultant value by 100.

N losses as compared to the amounts of fertilizer N and P applied. The greater losses of applied P are apparently due to the sorption of phosphate on soil colloidal surfaces (e.g., clays, hydrous oxides of Fe and Al) since the largest amount of P in runoff is carried by the sediment. In summary the quantities of fertilizer nutrients lost in runoff from the four soils do not represent significant monetary losses to the farmer and the nutrient losses are low considering the severity of the experimental conditions. The incorporation of the fertilizer would have likely reduced losses.

Water Quality of Tile Drain Effluents

A total of 283 tile drains in the Black Creek watershed were sampled in the spring of 1974 to obtain an estimate of solids, N and P concentrations in effluents from tiles draining agricultural land. The concentrations of NH_4^+-, NO_3^-, total N and total P in tile effluents are shown in Table 5 along with data for surface water samples collected near the outlet of the drainage ditch. For this and other water quality data presented, both the median and mean values were calculated. Because water samples collected during or shortly after a rainfall event may contain concentrations several fold higher than those encountered routinely, the median value is of interest when describing the "average" concentration of constituents in water samples. Inspection of the data in Table 5 shows that the mean value of most constituents is greater than the median; however, the mean and median may be comparable in some cases. The purpose of these analyses was to compare water quality in tile effluents and surface water; therefore median concentrations will be emphasized. It should be noted that the surface water data in Table 5 was obtained at only one sampling site while from 7 to 65 tile effluent samples were collected from each drainage ditch.

Tile effluents possessed greater concentrations of N than surface waters (Table 5). In many cases the median concentration of NH_4^+- and NO_3^--N was twice that found in surface water samples. With the exception of site 6, tile effluents contained elevated concentrations of total P when compared to surface waters. The increased total P levels at site 6 may be a reflection of domestic wastes originating from the town of Harlan. Based on this data, it is apparent that the significance of nutrient loss from agricultural land through tiles will be dependent on the quantity of water entering surface waters from this source. Assuming that 3.0 to 6.0 ha-cm (~3.0-4.5 acre-in) of water passes through tile drains and that NO_3^--N = 10mg/l, total N = 30 mg/l and total P = 1 mg/l, losses in tile drain effluents for NO_3^--N, total N and total P will be 7-16, 14-32 and 0.3-0.6 kg/ha, respectively. The rainulator data presented previously suggest that, on the average, 3.5% and 3.8% of fertilizer N and P are lost in surface runoff, resulting in losses of 5.9 kg N/ha and 2.1 kg P/ha. If both fertilizer and soil nutrient sources are included, total N and total P losses were from 11-42 kg N/ha and 2-9 kg P/ha for the rainulator plots. Thus, based on these results it appears that effluents from tile drains may be as important a mechanism for loss of nutrients from agricultural land as runoff of fertilizer applied to the soil surface and subjected immediately to an

Table 5. Nitrogen and phosphorus concentrations in tile drain effluents and surface waters.

Drainage ditch[a]	Type of sample[b]	NH_4^+-N		NO_3^--N		Total N		Total P	
		Median	Mean	Median	Mean	Median	Mean	Median	Mean
		mg/1							
Smith-Fry (2)	T	0.54	1.02	10.85	9.62	12.72	13.42	0.052	0.378
	W	0.25	0.35	5.70	5.47	6.82	6.55	0.152	0.240
Wertz (3)	T	0.36	0.51	7.33	10.20	12.20	13.95	0.028	0.060
	W	0.26	0.36	3.95	4.04	5.43	5.75	0.138	0.306
Gorrell (4)	T	0.40	0.56	4.41	4.57	9.09	8.92	0.096	0.236
	W	0.32	0.45	4.04	4.22	5.30	5.72	0.130	0.291
Richelderfer (5)	T	0.81	1.96	7.69	10.38	13.90	17.83	0.073	0.587
	W	0.51	1.04	5.20	5.26	6.62	7.38	0.435	0.621
Dreisback (6)	T	0.66	9.83	5.88	7.52	15.30	22.79	1.470	2.543
	W	0.50	0.87	3.90	3.91	6.03	6.16	0.436	0.628
Lake (7)	T	0.72	5.80	4.66	5.97	12.54	26.62	0.047	2.312
	W	0.21	0.34	5.60	5.72	6.84	7.10	0.162	0.340
Black Creek (12)	T	0.72	2.64	8.18	9.83	15.63	15.86	0.036	0.710
	W	0.26	0.40	5.07	5.02	6.20	5.98	0.192	0.364
Wann (13)	T	0.32	0.50	8.68	10.28	10.40	12.89	0.030	0.812
	W	0.20	0.28	3.92	4.10	5.10	5.18	0.102	0.227

[a] Number in parenthesis is the corresponding surface water sampling site.

intensive rainstorm. It must be realized that the nutrients in tile drains and surface runoff originate from fertilizers (both inorganic and organic) and from mineralization of soil N and P.

Water Quality of Surface Waters

The median concentrations for various constituents in water samples collected from March, 1973 to December, 1974 are presented in Table 6. Median values are used to indicate the predominant concentrations found. In general, water samples collected in the watershed (sites 1 and 13) contained lower concentrations of P and higher levels of N than samples obtained from the Maumee River (site 14). However, the distribution between soluble and particulate forms of N and P were similar in water samples collected from the watershed and the Maumee River. On the average, 83% of the total N was present as soluble species (i.e., NH_4^+, NO_3^-, and organic N) and 30% of the total P was in soluble forms. As discussed previously, this distribution between solid and liquid phases results from the capacity of suspended sediments to sorb soluble P whereas inorganic N, especially NO_3^-, remains in solution. A similar result was obtained for water samples from tile drains. The levels of soluble inorganic N and P were always in excess of the often quoted values limiting algal growth (i.e., 0.1 mg N/l and 0.01 mg P/l). However, concentration data must be interpreted cautiously because the total loading of N and P is the important parameter when considering the impact of agricultural drainage on the Great Lakes.

Instantaneous loadings were calculated for water samples obtained after installation of weirs at 7 sampling locations. The weirs were installed during February, 1974. From 50-60 samples per site are included in the loading data presented in Table 6. The median value of each loading is likely an approximation for the amount of material lost from each subwatershed during base flow. Because water samples are obtained weekly and whenever an event occurs, the mean is considerably greater than the median for all components in water samples. Obviously, extrapolation of instantaneous loadings to an annual basis is suspect at best, necessitating the use of automatic pump samplers to obtain accurate records of flow during an event. However, instantaneous loadings indicate differences between sites and the data also will be useful in evaluating models subsequently developed from pump sampler data. Preliminary data from the pump samplers suggest that total N and P losses during a single event range from 0.4-7.4 and 0.01-1.4 kg/ha, respectively. Extrapolation of instantaneous loadings to an annual basis yields losses ranging from 10-118 and 0.5-4.0 kg/ha/yr for total N and P, respectively. Thus, even though serious limitations exist in employing instantaneous loadings to calculate nutrient losses, the median values for nutrient loadings are realistic.

Table 6. Median concentration of water quality parameters for grab samples obtained from 19 March, 1973 to 29 December, 1974.

Site	Suspended solids	NH_4-N	NO_3-N	Soluble N	Particulate N	Soluble Inorg. P	Soluble P	Particulate P
		mg/1						
1	129	0.25	7.44	7.02	1.42	0.041	0.064	0.117
2	118	0.25	5.70	5.66	1.16	0.021	0.054	0.098
3	124	0.26	3.95	4.60	0.82	0.017	0.050	0.088
4	106	0.32	4.04	4.32	0.98	0.018	0.054	0.076
5	126	0.51	5.20	5.88	0.74	0.092	0.137	0.298
6	129	0.50	3.90	4.66	1.37	0.105	0.164	0.272
7	104	0.21	5.60	5.86	0.98	0.028	0.061	0.101
8	108	0.28	2.23	2.84	0.80	0.033	0.067	0.132
9	128	0.40	3.29	4.28	0.90	0.150	0.200	0.220
10	115	0.88	3.34	5.48	1.16	0.270	0.335	0.435
11	114	0.26	6.66	6.51	1.28	0.029	0.063	0.127
12	115	0.26	5.07	4.93	1.28	0.029	0.066	0.126
13	109	0.20	3.92	4.44	0.65	0.012	0.033	0.069
14	126	0.23	2.96	3.68	0.74	0.073	0.106	0.252

Table 7. Instantaneous loadings for components in surface waters.

Site	NH_4^+-N		NO_3^--N		Total N		Sol. inorg. P		Total P	
	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean
	g/sec									
1	0.03	0.15	1.39	2.26	1.27	3.47	0.005	0.013	0.024	0.091
2	0.15	0.33	3.03	4.66	3.31	6.07	0.011	0.032	0.070	0.406
3	0.02	3.05	0.33	55.65	0.52	77.02	0.001	1.431	0.005	10.352
4	0.04	0.15	0.49	1.48	0.67	1.70	0.002	0.014	0.014	0.111
5	0.02	0.28	0.23	5.39	0.25	5.34	0.005	0.104	0.014	0.543
6	0.06	0.16	0.79	1.45	1.13	1.88	0.021	0.052	0.090	0.313
13	0.20	20.82	4.65	90.27	5.51	123.25	0.012	0.603	0.118	19.148

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EFFECTS OF LAND TREATMENT ON THE AQUATIC ENVIRONMENT

by

James R. Karr* and Owen T. Gorman**

ABSTRACT

A fundamental assumption of the Black Creek Study is that the Universal Soil Loss Equation is the best estimator of the sediment potential of a watershed. It may be the best estimator of soil loss from small areas, but evidence from an intensive study of a forest plot on the Wertz Drain suggests that this assumption may be invalid at the watershed level. The average suspended solids load of the Wertz Drain in agricultural areas above and below the forest is 90 to 95 mg per 1 while at the downstream end of the forest the average is near 74 mg per 1. As the stream flows through the forest it acts as a natural sediment basin, reducing sediment load by about 28%. Furthermore, the biota reflects the relatively high water quality in the forest. Because of the shading by trees and the meandering nature of the stream inside the forest, temperature, oxygen, sediment, and nutrient regimes are more buffered than in channeled areas. This results in fewer algal blooms and a more stable (also more diverse) resident fish fauna than is found in other nearby streams.

Seasonal influxes of fish from the Maumee River spread through the entire Black Creek Study Area in the spring and in late summer. These fish are in search of suitable spawning and nursery areas. Bridge construction at Ward Road and rip-rap, in association with stage-recorder weirs, temporarily blocked fish movements into several of the tributaries of Black Creek in 1975. Smaller numbers of fish entered Black Creek in 1975 than in 1974; reductions in large fish were particularly striking. Fish populations also declined following bank reconstruction. The extent to which fish communities did not regenerate due to the reconstruction or due to stream blockages is not clear. Available evidence suggests that both factors are very important. Preliminary studies of age and growth of Black Creek fish show that the maximum age is lower and the size at any age is often smaller than for other populations of the same species. Problems of low growth rates, declining populations, and reductions in spawning and nursery areas for fish suggest that we should strive for more improvements in the quality of our water resource systems. Several recommendations are made for the development and implementation of future projects.

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INTRODUCTION

Borivli National Park near Bombay, India has been protected from clearing of forests to preserve the watershed as a source of pure water for the city. This policy explicitly recognizes

(1) that the terrestrial environment influences the quality of run-off water from an area, and

(2) the dependence of human society on a reliable source of high quality water.

It is gratifying to see a land management policy with such foresight in a region with high population and consequent pressure for food production and other land use.

Unfortunately, land use management policy in North America (and in most of India) has involved the clearing of natural vegetation. Because of the needs of our advanced industrial society, it is rarely possible to manage natural drainage systems to ameliorate the effects of human activity and insure a supply of high quality water. We depend on management of urban, industrial and agricultural systems to minimize effects on water resources, while simultaneously maximizing the benefits produced by industry and agriculture. Since it is virtually impossible to optimize for several factors simultaneously, compromises are inevitable.

The Black Creek Sediment Control Project has been designed to measure the effects of "various land use and agricultural practices on erosion and resulting effects on sedimentation and water quality." The present paper is an attempt to synthesize results of biological studies conducted as a portion of the Black Creek project. These studies were not initiated in their present form until the late spring of 1974, well after the other aspects of the project were under way. Before presenting the details of the Black Creek work, I shall summarize the results of selected earlier studies on rivers "as expressions of their terrestrial environments" (1). This will be followed by a brief review of the characteristics of the Black Creek Basin and selected results of our studies through October 1975. Finally, recommendations for further work, either as part of the Black Creek Project or other studies, will be suggested.

STREAMS AS ECOLOGICAL SYSTEMS

At least as early as 1901 scientists recognized the connection between water bodies and the lands and atmosphere which surround them (2). Any attempts to maintain or improve the quality of a water resource must recognize that interrelationship. All of the organisms in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure, energy flow, and nutrient cycling comprise a primary unit of study, the ecosystem. Only by employing the multidisciplinary approach to ecosystem management can we expect to manage wisely over the long term.

Some would maintain that "the various forms of life in a river are purely incidental, compared with the main task of a river, which is to conduct water run-off from an area toward the oceans" (3). Viewed from the perspective of a geomorphologist thinking in millions of years or an engineer attempting to control the river this may be true. But, I believe, a word of caution is in order. The living systems in and around rivers determine to a great extent the quality of water in a stream. As such, those living systems are of major importance in the development of policies for the management of a water resource. When we consider man and his crops and livestock we include a major component of the living system associated with our rivers and even the most near-sighted among us would not call these components of the living system "incidental."

In a project like the Black Creek Study it is important to recognize the many factors which impinge on the system. We have attempted to summarize those factors in Fig. 1. Since we are primarily concerned in the present project with the quality of outflow water, we have concentrated on those factors which bear direct effects on water quality.

Three external factors are of primary importance in determining characteristics of both the terrestrial and stream environments. These are the sun, the ultimate source of virtually all of the energy in biotic systems, the atmosphere, including wind, particulate matter, CO_2 and O_2, and climatic patterns. The latter includes amount and seasonal distribution of rainfall as well as temperature and humidity.

The terrestrial environment develops as a consequence of the interaction of these external factors and, among other things, parent material and topography. These factors and associated biotic communities determine the nature of soils developed in an area. Man's activities as a consequence of urban, agricultural and industrial needs impinge on all of these factors to govern inputs of nutrients, chemicals, allochthonous forms of energy, sediment and other characteristics which affect the quality and quantity of runoff water entering the stream system.

In the stream the quality and quantity of water (including its seasonal distribution) and bottom type and gradient characteristics of the stream bed affect the development of the biotic community of the stream. For small streams like those typical of Black Creek, energy from allochthonous sources provides most of the energy input to the biotic community. A major energy pulse develops in the fall, for example, with the input of leaves from plants in the surrounding terrestrial environment. As mentioned above, all of these factors interact in very complex ways to affect the quality of water exiting the system.

Clearly, the major impact of man in recent decades has been negative and we are now making major efforts to reduce those impacts within the constraints of satisfying the demands of human society. Too frequently, in my opinion, our efforts are directed toward the goal of conquering the natural system and its delicate balances. With wise use we can take advantage of the natural purifying characteristics of the land-water system to clean the effluents of human society. What we need is more knowledge of the capabilities of that system and the technological foresight to use those capabilities wisely.

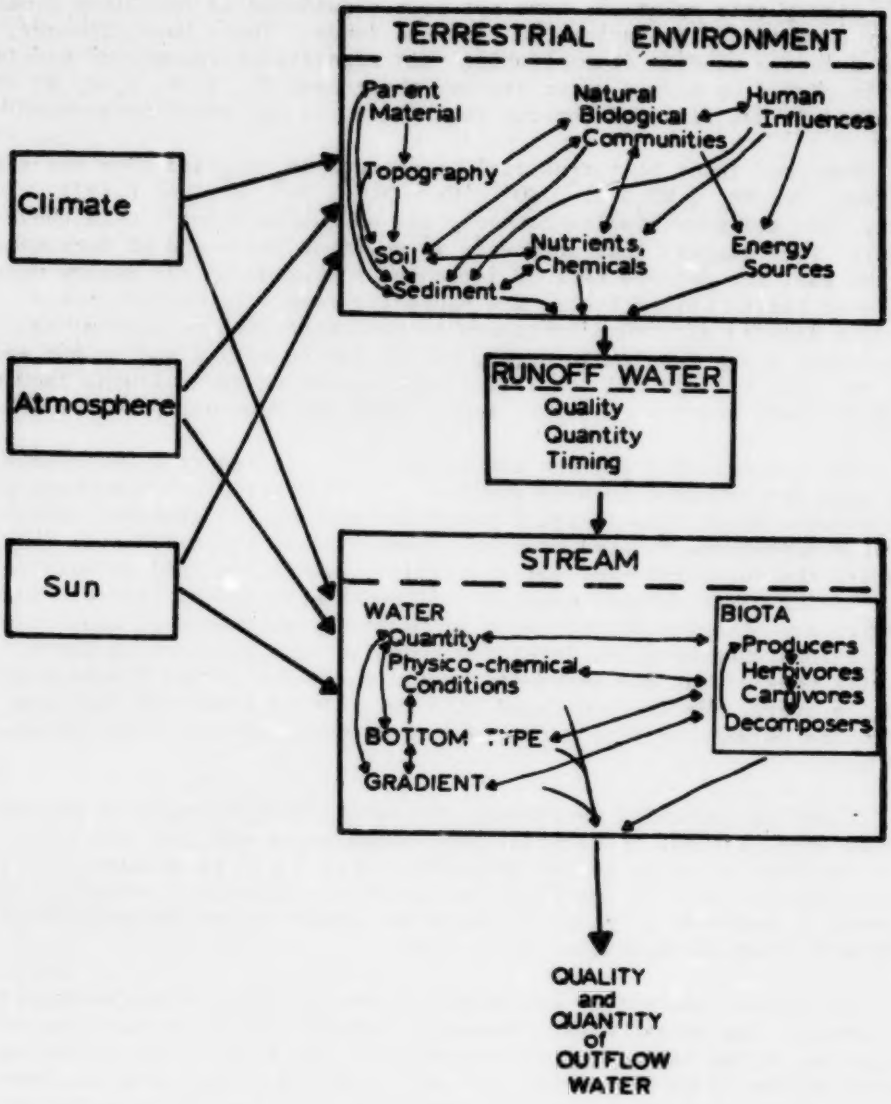

Fig. 1. General Model of the Primary Factors Governing the Quality and Quantity of Outflow Water from an Ecological System.

EFFECTS OF MODIFYING NATURAL HABITATS

Atmospheric relations have not been considered in the Black Creek Study because of limitations on time and funds. There have, however, been numerous studies demonstrating that significant amounts of nutrients may be picked up before water reaches the ground (4, 5, 6, 7, 8, 9, 10) or after it has filtered through vegetation (11 and above references).

Nutrient input to terrestrial ecosystems in rain and snow are significant for NH_4^+, NO_3^-, Cl^-, SO_4^{2-}, Ca^{2+} Mg^{2+}, Na^+, K^+, and P (12). In fact, rain and snow samples commonly had pH values below 4.0 in their study. They suggest that increases in nutrient loads and pH decreases in the past two decades reflect increased pollution of air masses passing over their Hubbard Brook, New Hampshire area. In western North America Hart et al. found increases in concentrations of sodium, calcium, magnesium, and potassium in precipitation during spring and summer and suggest that tillage and fertilizer application on agricultural land upwind of their study plots might account for the seasonal patterns (7).

The connectivity between rivers and their terrestrial environments has been demonstrated in many studies. It is particularly heartening to see concern about this factor in studies relating to relatively unexploited ecosystems in some tropical areas. Sioli (1) and Janzen (13) discuss the interaction of soils, climate, vegetation, and animals in determining physical and chemical conditions of tropical rivers. Their results are of major significance to further development in many tropical regions. Regrettably, development of land use patterns in North America have oftentimes proceeded beyond the point of preservation of fragile areas. We are now faced with the task of modifying land use practices to halt or retard the rate of deterioration of land and water systems.

There is generally an increase in runoff with increase in precipitation (Fig. 2a) but in natural plant communities sediment yields do not show the same relation to precipitation (Fig. 2b). Below about 300 mm of precipitation there is insufficient runoff for sediment transport. Decreases in sediment as rainfall increases above 300 mm are associated with more complex vegetation cover (14).

As natural ecosystems are modified several changes in the aquatic environment can be expected. Seasonal changes in peak stream flow become larger as do the variations in temperature. In effect, the buffering capacity of the vegetation cover is lost. Over the short term the erosion loss of particulate matter is low following clearing, while mobilization of nutrients from the available nutrient and organic matter compartments of the ecosystem proceeds rapidly (15). The natural ecosystems exert considerable control over erosion loss for at least 2 years after clearcutting. In the third and subsequent years the erosion loss increases exponentially because the buffering capacity of the natural system is overcome. This cycle serves to maintain the natural system by preserving particulate matter while making increased amounts of nutrients available to early successional communities. Repeated long term disturbance results in high erosion and rapid loss of nutrients, a situation which is exacerbated by continual cultivation. The need for fertilizer supplements on agricultural land further increases nutrient loads entering waterways.

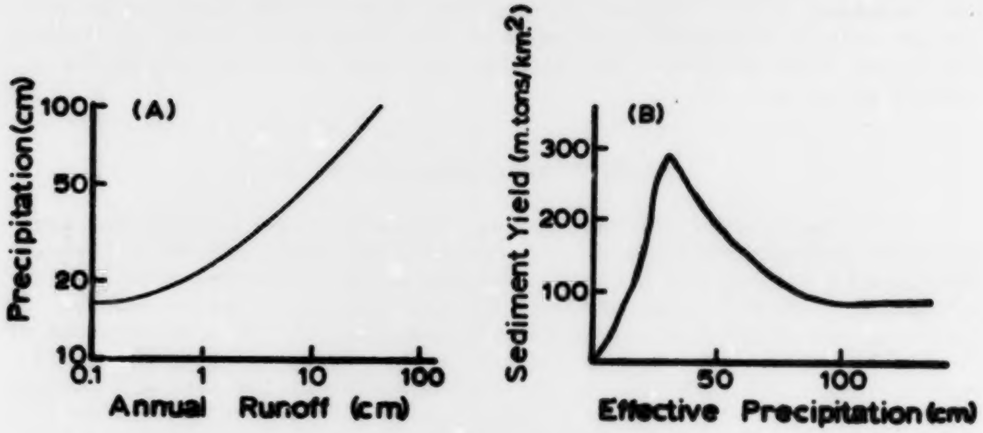

Fig. 2. General Relationship Between Runoff and Sediment Yield and Precipitation (Modified from Ref. 14).

Hydrologic effects of forest clearing include increased annual runoff (up to 40 X), especially summer runoff due to removal of transpiring surfaces and eventual streamflow reduction attributed to reduction in precipitation (16). In addition to these changes, the loss of vegetation cover results in earlier and more rapid snow melt on the watershed (17). Overall the probability of flooding increases and seasonal excesses or shortages of water are more common on deforested land.

As early as 1934 a study on the Bent Creek Experimental Forest in North Carolina demonstrated the impact of land use on flow rates of streams (18). The runoff coefficient, a ratio or runoff to rainfall considering factors such as slope, shade, cover, soil, geology, etc. was low on forested lands (0.07 to 0.11), and high on agricultural land (0.40 to 0.76). Similarly, peak discharges per square mile were very high on an abandoned agricultural watershed (52 to 750 cfs) but low on a forested watershed (5 to 28 cfs).

As a result of clearing land and increase in nutrients in streams, summer water temperatures increase and algal blooms occur in response to availability of light (stream no longer shaded). In addition, increased rate of runoff produces higher stream velocities resulting in more severe erosion in the stream channel. Fast release of water following loss of vegetation cover has resulted in downcutting of stream channels by several feet in extreme circumstances (18).

Siltation is another major pollution problem with the clearing of natural plant communities. The problem of siltation has worsened in large rivers such as the Illinois River in recent decades apparently due to the increased plantings of soybeans and also the use of heavy, powered farm machinery (19). Smaller streams like those in the Black Creek system may silt in seasonally, but much of the finer material may be flushed out during flood periods. The sediment may then become a problem for downstream areas.

EFFECTS OF CHANNELIZATION

Following clearing of land for agricultural or other purposes, man has often encountered flood or drainage problems which prevent or at least modify his use of the land. Various forms of channel modification to control runoff rates are used by many agencies to solve flood, drainage, and related conservation problems. Regrettably, major areas of our stream systems have been subjected to the extreme of channel modification despite the fact that it is "at the bottom of the list of measures to be employed in watershed development" (20). On the negative side the effects of channel modification include destruction of existing and potential recreational areas, alteration or destruction of fish and wildlife habitat, destruction of bottomland timber resources, and the permanent alteration of the natural beauty of an area. More severe downstream flooding is another common hazard of channelization. On the positive side channel modification may result in the development of a navigable stream, local flood control, and improved drainage allowing increases in arable land, among others (21).

Since this paper deals primarily with the impacts of land use on aquatic biota, we shall focus on discussion of the biotic systems. A number of recent studies (e.g., 21, 22, 23, 24) have compared channelized and unchannelized portions of streams yielding the following general conclusions:

(1) Channelization reduces complexity of the stream (pool-riffle complexity, meandering topography to straight ditch), reduces the length of the stream and typically makes the stream shallower.

(2) Reduced stream lengths result in an increased gradient and higher flow velocities. Channel erosion may be extreme as streams attempt to re-establish the original gradient. This problem can be reduced but not avoided by producing well-sloped and seeded banks.

(3) Greater daily and seasonal changes in water temperature with more extreme means are typical of channeled streams.

(4) Turbidities are consistently higher in channelized areas.

(5) Benthic invertebrate communities are less diverse in channelized areas because of the lack of diversity of colonization sites.

(6) Standing crops of benthic insects commonly decline following channelization. In one study there were 68 g per acre-foot in an unchanneled area of the Missouri River but only 8 g per acre-foot in channelized reaches.

(7) The number of fish species usually declines in channeled areas and there is often a shift from game to non-game species. Extensive sedimentation resulting in the loss of pools and tremendous water level fluctuations are limiting factors resulting in loss of sport fishes.

(8) Number of individuals and total fish biomass is lower in channeled areas; the standing crop of catchable fish declines in channeled areas.

(9) Population structures shift to a predominance of smaller fish in channeled areas. This may be due to mature fish moving out of the area, or more likely to shortened lifespans and slower growth rates (see Growth Rates of Black Creek Fishes below).

(10) In the Chariton River in Missouri "the combined effects of a poorer environment and reduced stream length resulted in an estimated 87.0% reduction in total standing crop (of fish) in the studied channelized section" (24).

(11) Over time many characteristics of the biota regenerate, with fish recovery occurring in about 15 years when measured by species diversity. Other measures of quality (species composition, biomass, etc.) respond more slowly.

In an extensive study of the streams of Champaign County, Illinois, Larimore and Smith (25) showed that drainage activities lowered the water table, eliminated marshes and ponds, and caused extensive fluctuations in flow. All of these factors had a significant negative impact on the fish communities of the county.

Clearing and modification of streambanks may also be undertaken in an effort to "beautify" a section of stream. Often such activities result in significant negative effects because original streams are often in a dynamic equilibrium with terrestrial environments. Accelerated erosion, bank slippage, and reduced stream productivity are consequences of poorly planned bank modifications (26). Although it is not often realized these alterations may reduce the ability of a stream to effectively deal with the pollutants of a modern society; that is, the stream may act as a natural purification agent in a more or less natural state but after modification by man that facility is lost.

THE BLACK CREEK SYSTEM

The Black Creek Study was initiated by the Allen County Soil and Water Conservation District with technical assistance from the Soil Conservation Service and Purdue University. Project objectives include demonstration and evaluation of methods for reduction of sediment and related pollutants in the Maumee River by control of soil erosion. Funding for this effort has been granted to the district by the Environmental Protection Agency under Section 108--Demonstration Grants. The Black Creek Basin was selected as a demonstration watershed representative of the Maumee Basin. The Soil Conservation service was to determine the types of land treatment to be applied to the watershed and Purdue University developed a detailed research and monitoring program.

The Black Creek Study Area is an area of 4870 hectares which drains into the Maumee River through Black Creek in northeastern Allen County, Indiana. As one moves from the northwest to southeast across the basin (Fig. 3), three major land types are encountered. The first is a region of rolling uplands of glacial till followed by a beach ridge area associated with the margin of the old Lake Maumee. Indiana Highway 37 parallels the edge of the band of old shore line deposit material. The area then slopes down quickly to a level area of wave-scoured lake-bottom tills. Topographic relief is generally low except in selected areas of the uplands in the northwest or in the entrenched areas of Black Creek near its junction with the Maumee River.

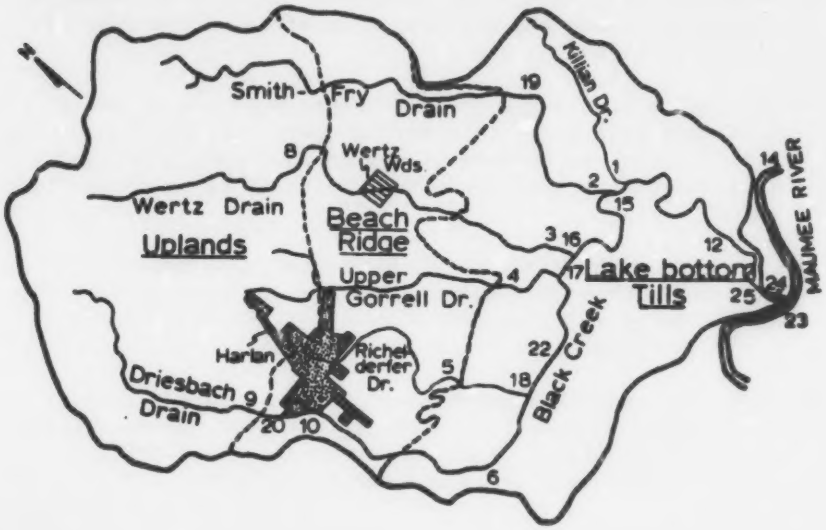

Fig. 3. Map Showing Major Features of the Black Creek Basin. Numbers Indicate Locations of Fish Sample Stations.

Climatologically, the area is in a continental climate receiving about 900 mm of rainfall per year with a mean annual temperature near 10 C.

Following the recession of the recent glaciers and the old Lake Maumee the Black Creek Basin was probably a mosaic of oak-hickory forest on upland areas with swamp associated forest and even some marshland on the lower less well-drained areas. At present 96% of the area is devoted to agricultural activities, mostly in cropland (81%), while the remaining 4% is devoted to urban and built-up activities. The small unincorporated village of Harlan is located in the western end of the basin.

Streams in the area consist of an east flowing Black Creek with five tributary streams flowing south to intersect the main Black Creek channel. All of the major tributaries (Driesbach, Richelderfer, Upper Gorrell, Wertz, and Smith-Fry Drains) have their origins in the upland area, flow across the beach ridge, and intercept the main Black Creek channel in the area of the lake bottom tills. The major features of the watershed are summarized in the accompanying map (Fig. 3).

All of the streams have been subject to varying degrees of channel modification in the past 50 years. In the late 1920s and early 1930s, the main channel of Black Creek was dredged to lower the water table and speed drainage. Since that time the major drains (Driesbach, Richelderfer, and Smith-Fry) have been cleaned with a combination of bottom-dipping and brush removal on a 15 to 20 year rotation, the most recent major work occurring in the early fifties. The smaller drains (Upper Gorrell and Wertz) are smaller and channel maintenance has been the responsibility of individual landowners. The magnitude of channel modifications on these drains have been less than in the other drains. One large project to clear the Wertz Drain was undertaken in the mid to late fifties. One small forest area on Wertz Drain (Fig. 3) has been undisturbed in recent years and is a major study plot for the biological studies.

RESULTS

The work undertaken as part of the biological studies on the Black Creek project have covered a wide range of subjects from the effects of streamside vegetation on suspended solids to several aspects of population and community dynamics of fish. It is not possible to outline all of these studies in detail at this time, so some of the highlights will be discussed. Although we do not expect the major conclusions presented here to change significantly with further field work, the precise quantitative aspects of results may change as more data are collected and analyzed.

Water Quality in the Wertz Woods Area

Laboratory methods: All water samples for the Black Creek Study are analyzed in the Water Quality Laboratory of the Department of Agronomy, Purdue University. Routine analyses include suspended solids and nitrogen and phosphorus components. Generally, methods are those of Methods for Chemical Analysis of Water and Wastes (EPA-1971). Comprehensive outlines of laboratory procedures can be found in the operations manual for the Black Creek Study (27).

Results: The general program of water sampling in the Black Creek Study involves routine and often automated sampling of water at a number of locations around the watershed. While the sampling effort yields large amounts of data on the nature of outflow waters, detailed intra-watershed variation due to vegetation types, and other factors is not adequately monitored. In an effort to resolve that problem, at least in part, the section of the Wertz Drain between Knouse and Antwerp Roads was selected as an intensive study site (Fig. 4). Between those two roads there is about 1800 m of stream channel, of which about 550 m meanders through a small patch of mixed forest. Tree dominants in the forest include oaks (*Quercus*), hickories (*Carya*), maples (*Acer*), and beech (*Fagus*).

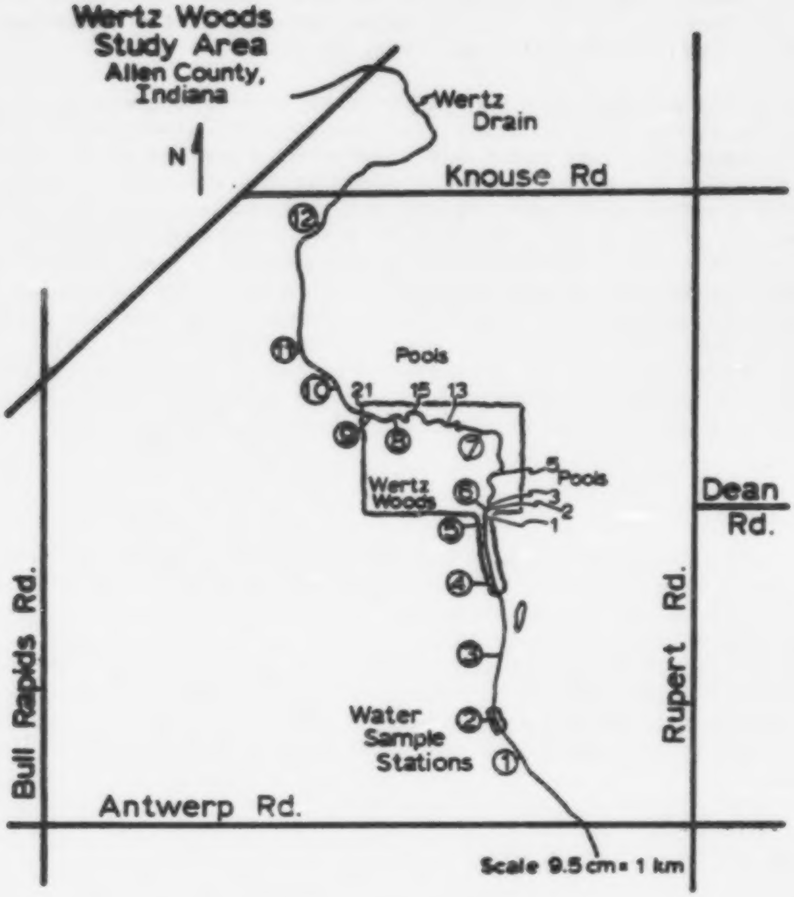

Fig. 4. Detailed Map of Intensive Study
Area Around Wertz Woods.

Several sets of water samples were taken in the forest tract in 1974 (Fig. 5). These showed a significant decline in suspended solids as the stream flows through the forest, and stimulated the development of a more extensive sampling procedure. Within the 1800 m section of stream, 12 sample stations were established. Three upstream stations (#10-12) are in a region of grass waterway bordered by agricultural land. Stations 6-9 are within the main woodlot area and 4-5 are in a small extension of forest bordering the stream. The remaining stations (1-3) are in a region of grass waterway bordered by agricultural land. Station 2 is on a bend in the stream in an area with several large cottonwoods (Populus). A steep badly eroded bank is located just above station 2. Inside the forest no grass stabilizes the bank, and the stream forms a complex of pools and riffles meandering widely through the forest. Just below station 7 a badly eroded tile drain enters the main channel.

Since February 1975 we have collected water samples regularly from the Wertz Drain. On 11 October 1975, we obtained our normal complement of 12 water samples plus two extra samples from each of the six even-numbered stations. Although some results indicate high variation among

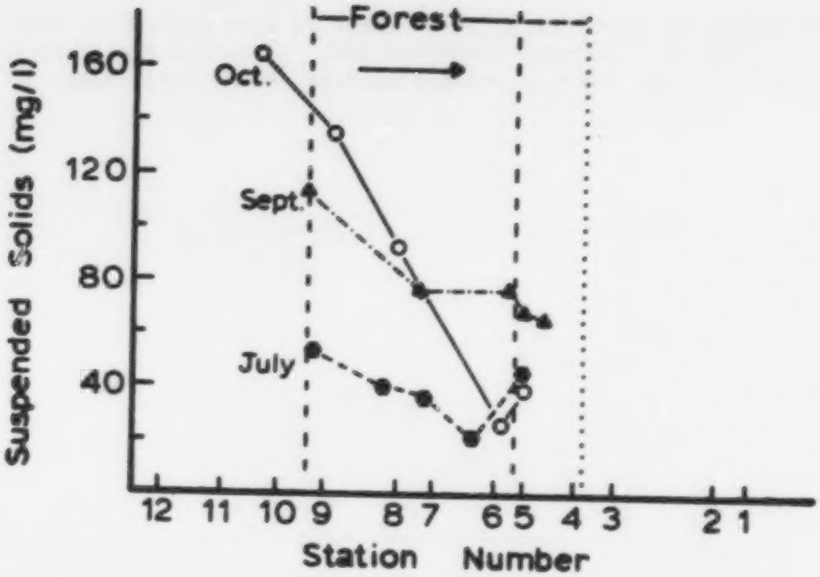

Fig. 5. Suspended Solids Load in the Wertz Woods Section of Wertz Drain, 1974 Samples.

the samples, the overall variability suggests the reliability of the laboratory procedures (Fig. 6).

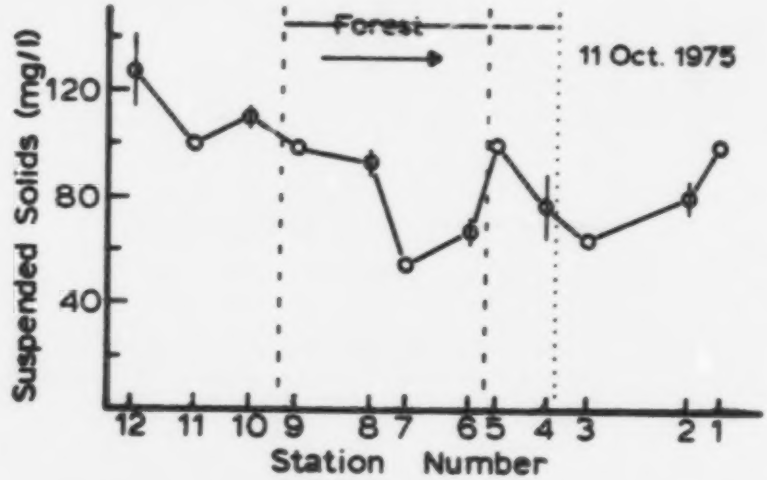

Fig. 6. Suspended Solids Load for Wertz Drain Study Area. Single samples were taken from odd-numbered stations, while three samples were taken for even-numbered stations. Mean (circle) and standard error of mean (vertical line) shown for even-numbered stations.

One might expect the sediment load of the stream to increase with increase in volume of flow. However, when all data for station 6 are plotted, no trend is evident for the range of lfow rates typical of 95% of the flow (Fig. 7a). Furthermore, there seems to be no major trend in sediment load with season (Fig. 7b). There is some indication that early and late in the year sediment loads are low. Loads are higher in early summer (May-June) and seem to decline in late summer (July-August). The late summer decline is probably associated with the development of high-density vegetation cover during that period. Early fall increases in sediment load may be due to the harvest season and the decline in plant populations.

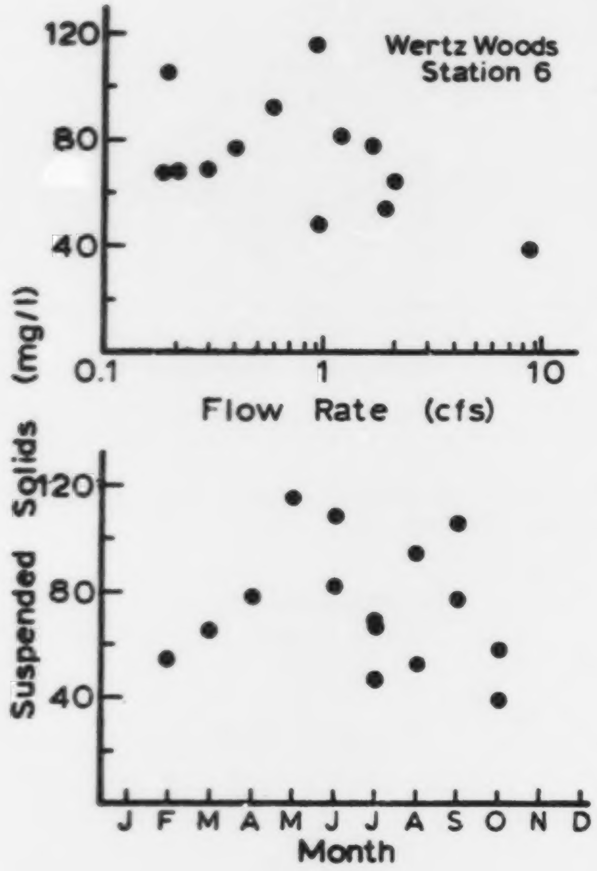

Fig. 7. Relationship Between Suspended Solids and Flow Rate and Season for Water Sample Station 6 in the Wertz Woods. Data from July 1974 to October 1975.

When all data for each sample station are utilized we can determine the mean and standard error of the mean for the sediment load at all stations (Fig. 8). Clearly, there is a striking decline in the sediment load as the water flows through the forest area. Furthermore, very soon after the stream leaves the forest, sediment load increases and stabilizes near a level characteristic of the Wertz Drain above the forest.

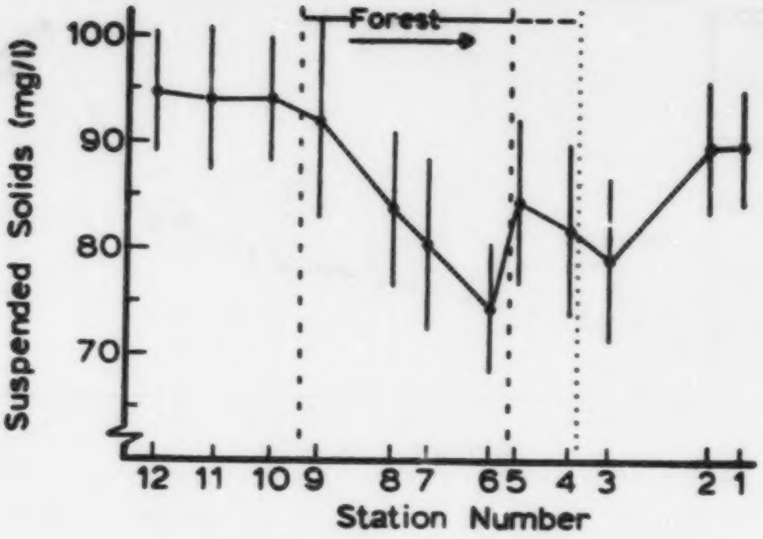

Fig. 8. Mean and Standard Error of Suspended Solids Load in Wertz Drain Study Area. Data from July 1974 to October 1975. Sample sizes vary from 12 to 16 at each station.

Variations within the agricultural and forested section of the stream are also of interest. For example, the typical increase at station 5 is apparently due to the nearby entry of a large drainage tile from adjacent fields. Considerable erosion is evident at that point. Note that even the presence of a small finger of forest extending south from station 5 results in a decline of sediment load to station 3. As the stream continues south to station 2 sediment loads increase significantly until they approach levels above the forest area.

A series of t-tests to determine the significance of variation in sediment load shows that stations above the forest are not significantly different in suspended solid content from the lower two stations. Stations 10-12, and 1-2 are significantly higher than stations at the lower end of the forest (stations 4 and 6) indicating that the forest acts as an effective sediment trap in reducing suspended solids by about 28%.

At very high stream flows, the forest apparently has little impact on reducing sediment loads. We obtained water samples shortly after a very heavy rain (about 10 cm in 2 hours) on 20 May 1975. From station 12 to 1 there was a gradual increase in suspended solids through the Wertz Drain Study Area (Fig. 9). Furthermore, the increased load of sediment seems to be a general phenomenon as the load increased from the headwaters of the streams to near the junction of Black Creek and the Maumee River (Fig. 9). These results suggest that the forest acts as a very efficient trap for removing suspended solids during most flow rates (>95%, Beasley, pers. comm.) but at very high flow rates the forest has no value as a sediment trap.

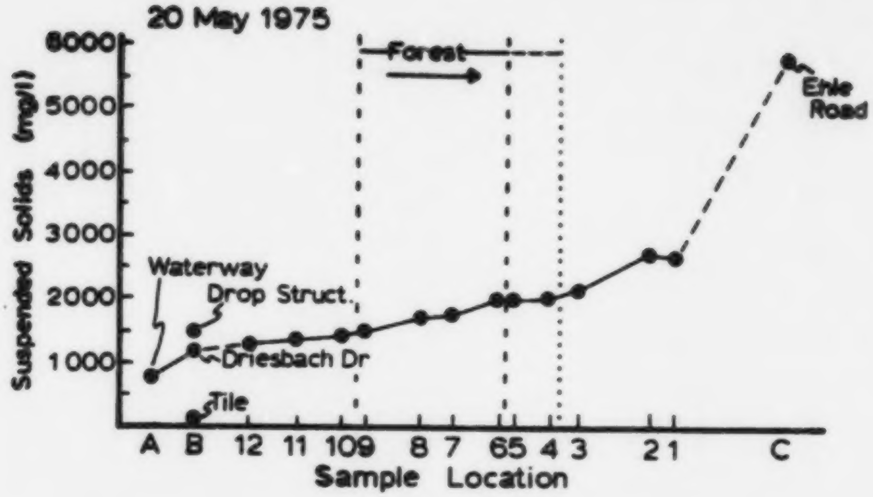

Fig. 9. Suspended Solids Loads on Morning of May 20, 1975 after Unusually Heavy Rainfall Event. Stations 1-12: Wertz Woods Study area. Station A: Driesbach Drain at lower end of grass waterway, near Cuba Road. Station B: Three samples (outflow of tile drainage, overflow from drop structure, and Driesbach Drain main channel) taken from Driesbach Drain at intersection of Grabill and Cuba Roads. C: Main Black Creek channel at Ehle Road.

The presence of the forest may, however, conflict with another of agriculture's needs in water management--rapid drainage to prevent or at least reduce water damage on agricultural land, Classical theory concludes that trees and brush act as obstructions to water flow and prevent rapid runoff and drainage. This slowing down of runoff might help downstream users of the floodplain, however, by giving a more controlled outflow of water on their lands, thereby reducing flood crests and flood damage. The conflicts involved in this problem cannot easily be resolved, particularly in view of the varying cost and benefit situations of different users of the water resource system.

A number of other water quality parameters are measured as outlined in the procedures manual for the Black Creek Study. Content of soluble nitrogen in the water increases significantly after the water flows out of the south end of the forest, although it does not change significantly between stations 12 and 6 (Fig. 10). The slopes of the curves are similar among the months but the heights of the curves vary. Generally, the values are high in the February to June period and low from July to October. It seems likely that the high nitrogen levels result from field runoff and are correlated with the seasonality of nitrogen fertilizer application and its availability at high levels in times of plant growth. Particulate nitrogen and nitrate (NO_3) shows similar variation among seasons and stations.

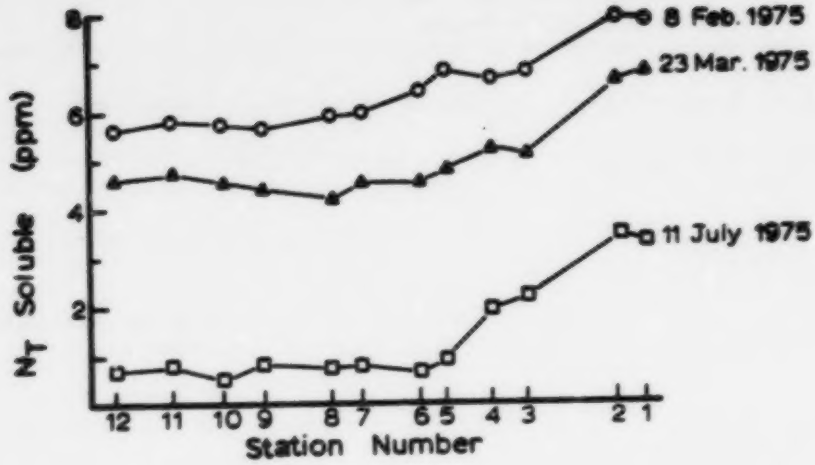

Fig. 10. Soluble Nitrogen Loads in Several Sets of Water Samples from Wertz Woods Study Area, 1975.

Other parameters of water quality (NH_4, and phosphorus in several forms) do not show any striking variation with season or among stations.

Fish Communities of Black Creek

Field Methods: Twenty-five sampling stations were established throughout the watershed to monitor changes in fish community structure (Fig. 3). Each sample station consists of a 100 m segment of stream. Visual observations are made at each station before quantitative samples are attempted. Fish samples are obtained by seining with 1/4-inch mesh minnow seines. A block seine is placed at the lower end of the sample station and the stream is seined downstream to the block seine. In areas that are difficult to seine we commonly make several sweeps to provide a more complete sample. In most areas only a single sweep with the seine is necessary.

For several months in 1974 most fish were kept to allow positive identification of fish and to provide specimens for food habits, fecundity, and age and growth studies. Continuing studies now involve identification and counting of fish and the return of fish to the stream. Intensive marking studies have been initiated in several sections of stream to monitor the stability of faunas in specific pools. Cold-branding with silver letters cooled in liquid nitrogen has been the most successful marking procedure to date. Several intensive studies of the structural diversity of stream channels are also in progress.

Species composition and distributions: A total of 29 species of fish representing 21 genera and 9 families have been collected in the Black Creek basin (Table 1). This represents about 17% of the species

Table 1. Fish Species Collected from the Black Creek Study Area and Their Status in the Basin.

Scientific (Common) Name	Status in the Black Creek Basin
Semotilus atromaculatus (Creek Chub)	Distributed throughout the area; some movements especially influx in spring.
Pimephales promelas (Fathead Minnow)	Most abundant in upstream areas.
P. notatus (Bluntnose Minnow)	Common throughout the basin but most abundant in small streams below *P. promelas* areas.
Ericymba buccata (Silverjaw Minnow)	Common throughout the basin especially in silty to sandy areas.
Campostoma anomalum (Stoneroller)	Uncommon but distributed throughout.
Notropis cornutus (Common Shiner)	Abundant to common throughout; some migration in spring.
N. stramineus (Sand Shiner)	Generally restricted to areas in the main channel of Black Creek; move upstream to some extent in late spring and early summer; often found in same areas as *E. buccata*.
N. spilopterus (Spotfin Shiner)	Common below station 12; uncommon in rest of basin except in fall when large numbers invade.
N. umbratilis (Redfin Shiner)	Rare throughout the basin, except in early summer.
Phenacobius mirabilis (Suckermouth Minnow)	Rare in Black Creek below station 15.
Notemigonus chrysoleucos (Golden Shiner)	Uncommon below station 12; resident population in Wertz Woods.
Cyprinus carpio (Carp)	Common and often large in main Black Creek channel; numbers declined after banks pulled in 1974.
Erimyzon oblongus (Creek Chubsucker)	Uncommon in basin except common in Wertz Woods.
Catastomus commersoni (White Sucker)	Abundant in sprint migration (esp. large individuals); permanent residents throughout Wertz Woods.

Table 1. (continued)

Scientific (Common) Name	Status in the Black Creek Basin
Carpiodes cyprinus (Quillback Carpsucker)	Common in Black Creek near Maumee River; sporadic in rest of area, most abundant in late summer and fall.
Moxostoma sp. (Redhorse)	One specimen.
Fundulus notatus (Black-striped Topminnow)	Common to abundant, esp. in areas with dense growth of aquatic plants and in late summer and early fall.
Percina maculata (Black-sided Darter)	One specimen.
Etheostoma nigrum (Johnny Darter)	Common, esp. in rocky areas.
E. caeruleum (Rainbow Darter)	Uncommon.
Lepomis cyanellus (Bluegill)	Common throughout.
L. macrochirus (Green Sunfish)	Common trhoughout.
L. microlophus (Redear Sunfish)	Collected occasionally.
Micropterus salmoides (Largemouth Bass)	Young sporadic in several areas.
Labidesthes sicculus (Brook Silverside)	One individual caught in Black Creek near Maumee River.
Ictalurus natalis (Yellow Bullhead) *I. melas* (Black Bullhead)	Small individuals sporadic throughout basin; some large residents in Wertz Woods and below station 12.
Esox lucius (Northern Pike)	Several large individuals seen or captured in spring 1974.
Dorosoma cepidianum (Gizzard Shad)	Common near Maumee River; many migrate upstream in late summer and fall.

and 33% of the families known from the State of Indiana (28). The minnow family, Cyprinidae, is represented by the largest number of species (12) with the bass family (Centrarchidae) being represented by the second largest number of species (4). The minnows make up the largest number of individuals in the basin but in terms of biomass the sucker family (catastomidae) is the dominant group, especially during the late spring and early summer migration period.

Early in the present century the eminent ecologist Victor Shelford studied the fishes of tributary streams that enter Lake Michigan near Chicago (29). He showed that longitudinal succession was a common phenomenon in streams; that is, as one moves from the headwaters of a stream towards its mouth the increase in stream size is accompanied by increasing diversity in the fish fauna. This is certainly true in Black Creek where downstream stations contain as many as 14 species in a 100 meter sample and upstream stations typically contain 2 to 4 species. At low flow seasons upstream stations may have no fish. In general, an increase in stream size is accompanied by an increase in fish species diversity. However, three other variables are particularly important in affecting fish community structure within the Black Creek Drainage. The three variables are:

(1) Season

(2) Degree of channel and/or bank modification, and

(3) Nature of terrestrial environment in the immediate vicinity of the stream.

Effects of season: Large scale migrations of fish from the Maumee River have been documented for the past couple years in late spring and late summer periods (Figs. 11 and 12). These migrations seem to be associated with spawning attempts as most of the fish moving upstream carry heavy loads of eggs and sperm. Species involved in spring spawning periods include white sucker, creek chub (Fig. 11), and the northern pike. In the spring of 1974 at least two and probably four large pike were captured or observed upstream in Black Creek as far as stations 18 and 20. The lengths of two of these fish were 51 and 61 cm.

A second group of species move into the Black Creek system during the late summer and fall. These include spotfin shiner, gizzard shad, and a carpsucker. The most comprehensive data are available for the spotfin shiner in 1974 (Fig. 12). Note that small numbers of relatively small fish are captured in the spring and summer while many larger fish are captured in the fall. By winter large numbers of young of the year are present, but all large spawners have departed. In March of 1975 large numbers of small yearling spotfins (weights less than 2.0 g) were moving downstream, presumably in search of the larger stream areas at the lower end of Black Creek and in the Maumee River. Small numbers of yearling spotfins were caught in the June through August period of 1975 and populations increased in September and October. However, the fall migration of 1975 had perhaps half the number of individuals of the preceding year and most fish were significantly smaller. Fish captured in 1975 had an average weight of 1.5 g while the mean weight in 1974 was slightly over 5 g. Furthermore, the distribution of spotfins was more limited in 1975 than in 1974. It is not possible to determine the precise cause of these changes in spotfin populations. Several alternatives are possible. High mortality of adults in the 1975 spawning season may be due to stream blockages. Alternatively, channel modifications in Black Creek channel may have reduced survivorship. Finally, heavy construction at Ward Road (station 12) in spring and summer 1975 may have prevented migration into Black Creek. There can be little doubt that these factors have had a significant effect on the fishes of several of our sample stations.

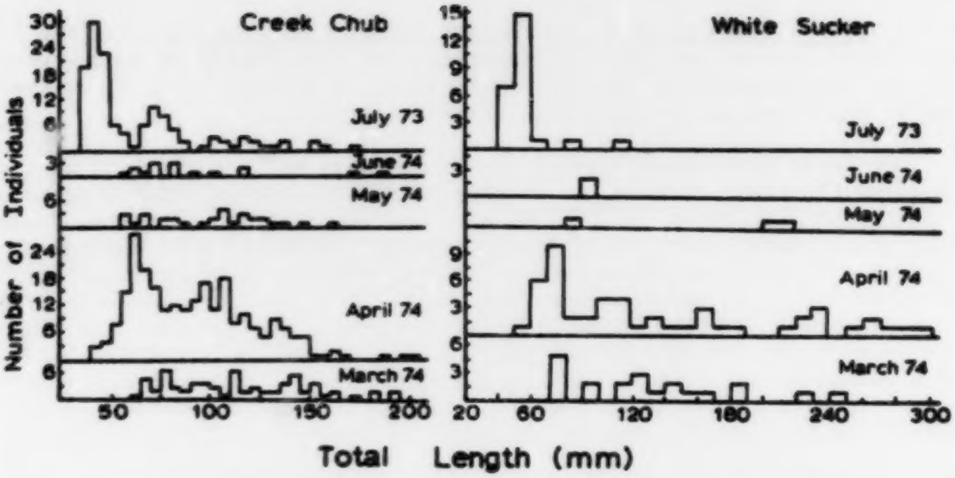

Fig. 11. Frequency Distribution of Total Lengths for Creek Chub (Semotilus atromaculatus) and White Suckers (Catostomus commersoni) Caught in Black Creek Drainage. Note that the proportion of large fish is high in the spring (spawning months). N.B. - The number of individuals captured varies from month to month due to different sampling intensity.

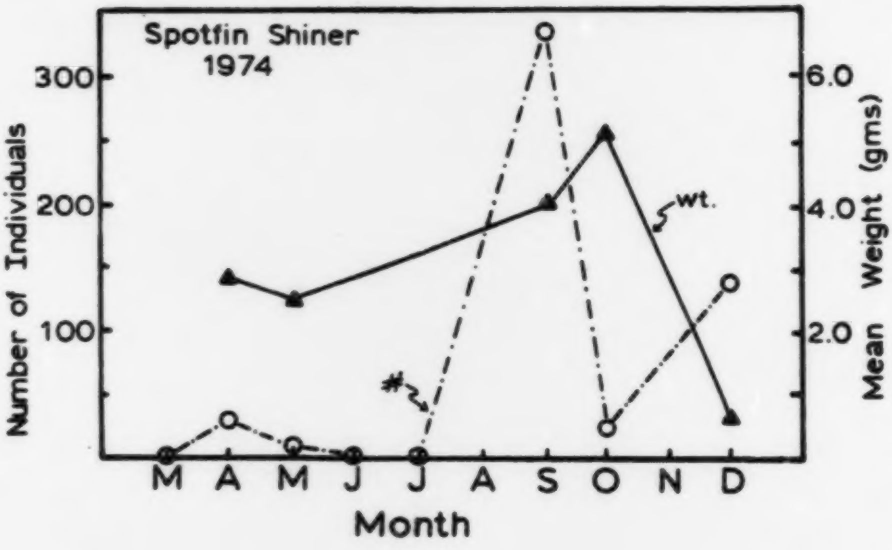

Fig. 12. Seasonal Changes in Spotfin Shiner Abundances and Mean Weights in Black Creek Above Station 12, March-December, 1974.

Effects of channel modification and terrestrial environment: The effects of channel and bank modifications can most easily be demonstrated by examining changes in the fish communities at station 15 on Black Creek and at the lower end of Driesbach Drain (station 6).

Our first 50-m sample at station 15 was made on 12 April 1974 when we captured 210 fish. Fifty-nine of these fish had average total lengths of over 150 mm indicating the high biomass in that section of stream. Larger individuals were creek chubs, white suckers, common shiners, and green sunfish. Capture histories for two 50-m sections at station 15 are given in Table 2. At the peak of spring migration densities are lower in 1975 than in 1974 indicating that the large spawning fishes are not reaching the area or are not able to use the area following the bottom dipping and bank modifications carried out in late spring 1974. Although densities are up in 1975 in the lower segment, fish size is small and biomass is low (Table 2). At the time of the April 1974 sample the stream showed

Table 2. Densities and mean weights for fishes captured at station 15 during 1974 and 1975. Two 50-meter segments to this sample station. The upper segment is now a straight channel without rip-rap while the low section is associated with an extensive rip-rap bank.

Date	Number of fish per meter	Mean weight (g) per individual	Biomass (g) per meter
Upper Segment			
1974			
12 April	4.20	25.85	108.6
20 May	1.00	12.71	12.7
14 Sept.	5.22	2.90	15.1
1975			
5 April	0.42	2.40	1.0
19 April	0.34	2.10	0.7
3 May	0.36	--	--
24 July	0.08	--	--
11 Oct.	0.20	0.92	0.2
Lower Segment			
1974			
20 May	1.04	6.79	7.1
1975			
5 April	2.74	1.43	3.9
19 April	5.14	3.40	17.5
3 May	1.62	2.48	4.0
24 July	4.02	--	--
11 Oct.	3.92	1.83	7.2

the effects of earlier channel modification but erosion and deposition areas with some segregation of particle sizes was evident. The mean depth of the stream was near 50 cm while following channel modification in 1974 water depth averaged only about 10 cm. The decline in fish populations at this station seems primarily attributable to the channel modifications reducing the depth and stream bottom diversity. However, from these data it is difficult to distinguish between the effects of stream modifications and barriers produced by construction activities.

Some indication of the relative effects of these two factors can be obtained by examining the capture history at station 6. Weirs with automatic water samplers were installed at several locations between 4 and 13 February 1974 including one about 40 meters downstream from station 6. In the spring of 1974 these weirs did not block fish migrations but following the addition of rock, some weirs became effective barriers to fishes. Station 6 exemplifies this situation (Table 3).

Table 3. History of captures of fish and disturbances at station 6, Black Creek at Brush College Road.

Date	Number of fish per 100 meters of stream	Mean weight per individual	Number of species
1973			
24 July	201	13.53	9
1974			
Feb.	Weir installed at Brush College Road		
5 March	301	9.87	8
12 April	69	5.70	7
	Stream channelized		
20 May	10	1.00	2
18 October	32	4.5	3
1975			
23 March	3	1.6	1
5 April	0	0	0
3 May	9	1.1	1
	Unusually heavy rains; floods		
29 May	174	Not weighed	9
16 June	63	--	6
25 June	129	--	10
10 July	68	--	8
24 July	105	--	8
26 August	94	--	9
26 September	63	--	11
11 October	20	5.52	5
11 October[a]	19	3.59	4

[a] Not including one large creek chub over 150 mm long.

Note that high populations and species numbers were recorded in summer 1973 and spring 1974 before the stream was channeled. After channelization there was a precipitous decline in number of individuals. Numbers remained low up to the present although the number of species has returned to 1973 levels. Under normal circumstances an increase in the number of fishes might be expected, even in a channeled area, with the spring migration. However, the weir and associated rock at Brush College Road prevented such a migration until the high water following the rains in May 1975. This 29 May sample contained large numbers of small fish although no weight data are available because the fish were returned to the stream. Note that while fish reached station 6 after the May storm, the major spawning runs of early spring 1975 had passed and reproduction was likely to have been too late and/or well below average. The blockages at the weirs have been removed so that should not be a factor in the spring of 1976.

Another incident demonstrates the effectiveness of the weirs in blocking fish movements. In September 1974 many spotfin shiners were captured in Black Creek. Near station 18 just west of Bull Rapids Road, one 50 meter sample netted over 100 spotfin shiners. Many spotfins were found throughout the east-west portion of Black Creek but very few were captured above the weirs on Black Creek and Smith-Fry and Wertz Drains. The water below the bridge at Brush College Road was swarming with spotfins but none were captured 40 meters upstream of the weir at station 6.

The construction of a new bridge on Black Creek at Ward Road may have been the most detrimental barrier to fish migration and reproduction in 1975. A large conduit pipe formed a sizable waterfall and torrent within the pipe, producing an effective barrier to even the largest fish attempting to reach spawning areas in Black Creek and its tributaries. On 19 April 1975 we sampled the pool just below the conduit and captured many large and small fish. Six large white suckers were captured in the small pool; they averaged 270 mm total length. When released they continued their unsuccessful struggle to move upstream.

All over the drainage, the combined effects of barriers and channelization were dramatic. Which is the most important is not easy to determine at this time because of the lack of controlled experiments. However, one thing is clear. If the fish cannot reach high quality spawning grounds, they will not reproduce and their populations may be doomed. This problem could result in a decline in fish abundance in Black Creek and in the nearby Maumee River, especially in those species which use the Black Creek basin as nursery and spawning grounds.

Our "control" stream, the Wan, just east of Black Creek is instructive. This stream was channelized about 5 years ago, but has no migration barriers to our knowledge. The history of fish captures at station 13 on the Wan shows consistently more species when compared to similar stations in Black Creek (Fig. 13). Data on weights also indicate larger and more stable average weight at station 13 than at station 6. Since the stream channel at station 13 has high densities of several aquatic plants, our sampling methods are inadequate for accurate determination of population densities. When one corrects for such problems densities are more stable, presumably due to the buffering effects of the vegetation and several deep pools which allow fish to survive through the rigorous summer and winter temperature extremes. Presumably even with channelization a stable fauna can develop after return of channel diversity and instream vegetation. The question is how does a "healed," channelized stream like the Wan compare to a natural stream?

We can most nearly approximate this in our studies in the forest on Wertz Drain discussed above. Observations to date show that these

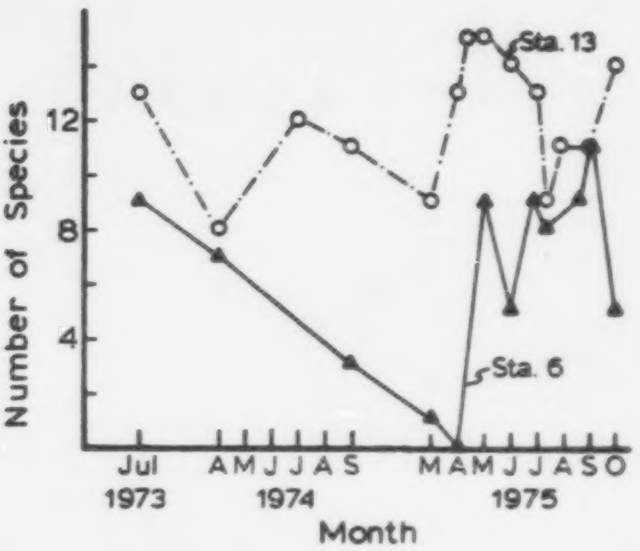

Fig. 13. Changes in the number of fish species caught in 100 meter samples from station 6 (Black Creek above Brush College Road) and station 13 (Wan Creek above Knouse Road).

pools and riffles house a rich and varied fish fauna, much of which seems to be resident throughout the year. During July of 1974 several days of intensive studies were conducted in the section of stream associated with the woods. Outside the woods in the channelized areas of the stream, few fishes could be found in the algae choked ditches where water temperatures reached as high as 28 C. Inside the woodlot the deep pools contained many fish and water temperatures were much lower at 19 C. In addition, no algal growth was noted. Over the past 18 months the general structure of the stream has remained stable by comparison to the ditches where pools may silt in rapidly (e.g., the settling basin) with heavy rainfall and whole banks may erode rapidly. In the forest large deep pools allow fishes to survive through dry periods in August and September while nearby, channeled areas of stream are either too hot, too choked with algae or dry. Pools, then, protected from the direct rays of the sun prevent the local extinction of fish populations in sections of streams where drought conditions allow little or no net flow.

An intensive survey of the fishes of several pools in the Wertz Woods in the period April to October 1975 demonstrate this. Each pool is seined after the stream above and below is blocked to prevent the escape of fish. Seining continues until the capture rate per seine haul approaches zero. Each fish is then measured and cold-branded to allow individual identification. Although individuals cannot consistently be found in disturbed areas like stations 6 and 15 we commonly capture the same individuals in the sample pools inside the Wertz Woods. In October, for example, 4 out of 10 fish captured in three different pools had been previously captured (Table 4). In addition, while the larger of these pools are only 20 to 25 meters long, they consistently contain many individuals of 8 to 10 species. Adults up to 20 cm long are not uncommon, and they seem to survive in the area throughout the year.

Table 4. Species composition, densities, and percent of individuals previously captured in three pools in Wertz Woods, 11 October 1975.

Species	Pool #3		Pool #5		Pool #15		Totals	
	Number of indiv.	% recap.	Number of indiv.	% recap.	Number of indiv.	% recap.	Number of indiv.	% recap.
Silverjaw Minnow	6	0	12	0	4	100	22	18
Bluntnose Minnow	4	0	28	42	21	19	53	30
Fathead Minnow	--	--	1	100	2	100	3	100
Creek Chub	14	57	21	42	26	19	61	36
Common Shiner	--	--	3	100	1	100	4	100
Stoneroller	--	--	--	--	1	100	1	100
Creek Chubsucker	2	0	--	--	8	62	10	50
White Sucker	2	100	9	100	14	78	25	88
Green Sunfish	--	--	2	100	1	0	3	67
Johnny Darter	1	100	17	17	7	14	25	20
TOTALS	29	37	93	41	85	40	207	40

Growth Rates of Black Creek Fishes

We have completed the first stage of our analysis of length-weight data for 12 of the more common fish species captured in the Black Creek Study area. Length-weight regression data are summarized in Table 5. A comparison of these data with the results of other studies is incomplete but suggests that growth dynamics of Black Creek residents is inferior to other populations of the same species.

Table 5. Summary of length-weight regression for fish collected in Black Creek, Spring and Summer, 1974.

Species		Intercept	Slope		r	N
Creek Chub	Log W =	-5.30	+3.21	Log L	.995	320
Common Shiner	Log W =	-5.44	+3.27	Log L	.956	97
Redfin Shiner	Log W =	-5.21	+3.18	Log L	.910	51
Spotfin Shiner	Log W =	-4.74	+2.85	Log L	.965	64
Silverjaw Minnow	Log W =	-4.97	+2.97	Log L	.944	159
Sandshiner	Log W =	-6.15	+3.66	Log L	.969	45
Stoneroller	Log W =	-5.30	+3.21	Log L	.975	30
Fathead Minnow	Log W =	-4.56	+2.81	Log L	.737	14
Bluntnose Minnow	Log W =	-5.11	+3.17	Log L	.973	24
White Sucker	Log W =	-4.99	+3.03	Log L	.997	63
Rainbow Darter	Log W =	-5.59	+3.42	Log L	.842	44
Johnny Darter	Log W =	-4.73	+2.87	Log L	.911	18

The scales of fishes often show growth rings by which the age of the fish can be determined. Although the method of aging by growth rings is not without problems (30, 31), some inferences about Black Creek fishes are possible.

Spotfin shiners from Black Creek have a maximum age of III which is not unusual for the species (Table 6). Maximum age for the species in the Des Moines River in Iowa was II (data from other studies are taken from the excellent summaries provided by Carlander, Ref. 31). The general similarities in the Iowa and Indiana fish are presumably due to the fact that both populations are dependent on a large river for food and habitat throughout most of their lives. As discussed earlier, this species is rare in the Black Creek drainage above station 12 except in the late summer and fall spawning season.

Creek chub on the other hand are resident in Black Creek throughout the year. Some large individuals seem to enter the stream in the spring spawning season. Creek chub from Black Creek have the surprisingly low maximum age of III whereas populations from other areas commonly include fish of age V and VI (Georgia, North Carolina, New York, Michigan, Iowa) with some even attaining age VII (Ohio, New York). This strongly suggests that Black Creek does not contain high quality creek chub habitat, especially for older individuals.

Table 6. Growth data for several species of Black Creek fishes.

Species	Maximum age class	Number of individuals[a]	Mean total length (mm)	Mean calculated total length at annulus formation (mm)			
				1	2	3	4
Spotfin Shiner	III	78	66.1	27.9	50.5	84.0	-
Creek Chub	III	177	114.2	56.4	93.6	134.3	-
White Sucker							
Combined	IV	94	84	57.3	88.8	131.1	172.6
Males	IV	29	101	54.3	82.9	132.7	177.9
Females	IV	40	93	61.0	92.9	127.2	162.1

[a] Scales read for this number of individuals.

The situation for the white sucker is similar in that the maximum age for Black Creek fish was IV while age VIII fish are not unusual and age X to XII fish have been recorded in several areas.

Generally, these data indicate that longevity in Black Creek fish is below that found in many areas. This is due to a complex of factors including habitat quality and stream size.

In addition to the reductions in maximum age just discussed, Black Creek fish tend to be smaller than (Illinois) or about the same size (Ohio, Oklahoma) at any age as fish from other areas. The situation is similar in white suckers. Populations from throughout the midwest have lengths at the third annulus of over 200 mm and often over 300 mm, while Black Creek fish have average lengths of 131 mm at the time of formation of the third annulus (Table 6).

It is clear that the growth of Black Creek fishes as measured by several parameters is inferior to many populations of the same species in other parts of the midwest.

DISCUSSION AND RECOMMENDATIONS

The decay in water quality experienced in recent decades is predictable from knowledge of the effects of clearing natural vegetation, modification of stream channels, and intensification of land-use by human society. Our problem is to manage urban, industrial, and agricultural man to minimize effects on water resources, while maximizing benefits to human society. Conflicts in short- and long-term goals are a major source of problems in the optimization process.

Although a model of sediment dynamics for a drainage basin is an admirable goal, evidence from a small study area in the Black Creek watershed suggests that small scale changes in land use may have a profound effect on sediment and nutrient dynamics. Caution should be exercised in the application of the Universal Soil Loss Equation to estimate sediment potential of a watershed. Small scale variation in the vegetation cover near the stream and characteristics of the stream channel (especially pool and riffle frequency and meander characteristics) are particularly significant. They affect the sediment and nutrient dynamics of the stream and the nature of the stream biota, a prime indicator of water quality.

In the future, management and research programs dealing with non-point source pollution problems (especially sediment and its causes) should:

(1) Understand small scale patterns in land use and how they affect sediment yields. This is especially important in the design of networks for collection of water samples.

(2) Integrate comprehensive biological studies in the early planning stages. The biota of an aquatic system is probably the best indicator of water quality.

(3) Develop a comprehensive information network to insure that all project participants are aware of management

and research programs. An unexpected change in land or stream-bank management can send shock waves through established research programs. Similarly, advanced warnings of changes can allow other researchers to generate new experimental studies.

(4) View the biota as an integral part of a very dynamic system. The biota must be monitored throughout the year rather than in only a single season.

(5) Ask how we can use the biota to clear the effluents of modern society. Many aquatic organisms will provide "free" effluent treatment service if we manage for that service.

The Black Creek Study is a model project for solving problems within the Lake Erie basin. By carefully evaluating the effects on the biota of activities in this study, we can more realistically predict the consequences of management alternatives on a wider geographic scale. The fishes of Black Creek are part of a complex food web which "feeds" the biotic systems of Lake Erie. Failure to maintain the biotic systems of Black Creek will inevitably result in failure at the level of the Great Lakes Basin. We can compare the small streams of the basin to the leaves of a tree (or corn plant). If the leaves, which feed the tree, are diseased the tree will not be healthy. The tree may even die.

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COMPUTER MONITORING OF ENVIRONMENTAL CONDITIONS IN A WATERSHED

by

L. F. Huggins*

Problems associated with collecting hydrometeorological data are typical of most "field" data which must be continuously monitored by unattended instrumentation. Currently, the vast majority of such requirements utilize numerous sensors each connected mechanically or electrically to an individual, strip-chart recorder. The most serious problems with such data acquisition techniques is that of transcribing these analog strip-charts into a computer compatible format for analysis and permanent storage. Transcribing procedures are labor intensive and, therefore, costly and error prone.

In addition, this transcribing usually necessitates a time lag of days to weeks between data acquisition and the availability of results for interpretation and dissemination. A second serious problem associated with the use of individual strip-chart records is that of time registration errors between multiple recorders, i.e. the indicated chart times from various recorders are all subject to different errors.

It appears that the situation described above is on the verge of rapid change. A period of intense effort directed toward the installation of field-based instrumentation designed to automatically acquire, monitor and file environmentally related data is at hand. True, the technological capability to accomplish these tasks has existed for several years; however, the cost-benefit relationship for such systems has generally been unattractive for all but specialized applications. Recent technological breakthroughs concerning inexpensive microcomputers and very low power integrated circuits have now provided manufacturers with incentive to develop general purpose, reasonably priced instrumentation suitable for automated field installations. The purposes of this paper are: (1) to discuss the implications of this trend as they relate to the environmental field, (2) to delineate the considerations important for implementation of automated field data acquisition systems, and (3) to outline the system, identified by the acronym ALERT, presently being installed in the Black Creek watershed.

GENERAL IMPLICATIONS

It is only natural when one considers selection of an automated data acquisition system to initially think only in terms of automating manual procedures. While situations exist for which this approach is the most appropriate one, careful consideration should first be given to the many potential benefits that may be obtained by computer controlled systems designed as complete integrated systems. In other words, in order to fully exploit the potential of a new technology it is often desirable to break substantially with previous methodology. A particularly good example of this relating to the selection of a data recording format has been outlined by Langham (1971) and will be illustrated in the subsequent discussion of the Black Creek ALERT system. Based on these considerations it is convenient to classify automated data acquisition systems as either data logging or computer controlled designs.

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The primary design objective of the numerous commerically available automatic data logging systems is to provide periodic scanning of multiple sensors (transducers). The resulting data is stored on a computer compatible media which will subsequently be transported to a remote (off-line) computer for analysis and filing. Some of the more sophisticated models have programmable alarm levels and remote activation as options.

The user benefits of data logging systems are: (1) reduction of the labor (and the long time delay between data recording and availability of the analysis) associated with strip-chart records; (2) elimination of the transcribing errors associated with converting the data into a computer compatible format prior to analysis and permanent file storage; (3) elimination of time registration errors that occur when each variable being monitored is recorded on independent clock-driven charts; and (4) the capacity of monitoring a large number of variables (channels) at a very small incremental cost increase, i.e. the primary expense is associated with the basic controller and recording device rather than with increasing the number of channels scanned. The price range of presently available data loggers is on the order of $2,500 to $10,000 depending upon the options and output media selected. Most of the presently available units require a-c line power for operation. In addition, almost all units require the associated sensors to present a voltage or current output proportional to the variables being monitored.

Computer controlled data acquisition systems differ from data loggers primarily in the size and sophistication of the unit, a full scale computer being used in the computer controlled system, employed to control operational sequence. In fact, since many of the data loggers utilize a programmable micro-processor as their control unit, the entire field of automatic data acquisition could logically be viewed as a continuous progression of devices rather than as two distinct classes. However, for the purposes of this presentation it is desirable to persist with the concept of two distinct categories, i.e. data loggers and computer controlled systems.

The computer controlled class of data acquisition systems discussed herein will refer to those installations which employ a full-scale computer remote to the transducers in the field to control acquisition, analysis and filing of the data. The computer, preferably some type of time-shared system in order to greatly reduce the cost allocated to the data acquisition function, would be in direct and continuous communication with the field transducers; such a computer is referred to as being "on-line". This class of acquisition system requires, in addition to an elemental multi-channel scanner based in the field with the sensors, a communication link over which to send data to the computer and a "port" or access connection to the computer itself.

While computer based acquisition systems are usually more expensive to install than data logging systems, their capabilities and benefits are dramatically greater. In addition to all the advantages of data logging systems they offer virtually instantaneous analysis of incoming data and the capacity for sophisticated monitoring of conditions in the field. This different level of analytical capability has several important implications.

Computer based data acquisition systems can be programmed to monitor incoming data and to automatically issue advanced warnings to public officials of impending hazardous conditions. This monitoring can be much more sophisticated than the simple alarm-level off-line recording of data logging systems. For example, while monitoring the rainfall intensity and flow distributions within a watershed, the computer could be programmed to recognize potentially hazardous rainfall patterns. Detection of such conditions would then automatically cause the computer to initiate a complete flood routing program to forecast water levels in the drainage system. If this routing indicated likely hazardous flood levels, responsible public agencies could immediately begin efforts to inform the public about appropriate courses of action.

Computer based acquisition systems normally provide a complete two-way communication link between the field instruments and the computer. Therefore, the transmission of information should not be restricted to only data from the field transducers to the computer. It is entirely feasible for the computer, on the basis of incoming data, to send information back to the field to effect control of all phases of the monitoring equipment, i.e. a closed-loop control situation. A simple example of such an application would be to have the computer control the time interval between water samples taken to determine pollution levels during rapidly changing flow conditions. Multiple parameter condition tests can readily be programmed into the computer which can then transmit operational commands to the field water sampling equipment. Such multiple parameter tests can serve to significantly improve the integrity of the resulting data by collecting samples frequently when conditions are changing rapidly. Simultaneously, laboratory analysis costs can be reduced because the sampling interval would be automatically increased during periods of slow change.

Still another important implication of computer based acquisition systems is their capacity to continuously verify proper operation of the field-based transducers. Such verification significantly improves the reliability of the data base and simultaneously provides more efficient utilization of technically trained staff servicing the equipment. This increased efficiency results from the elimination of much of the time normally required by routine site visitation to verify proper equipment operation.

SYSTEM DEVELOPMENT CRITERIA

Selection of a particular configuration of field transducers and equipment to automate a data acquisition process ultimately must depend upon the specific application, Barrett, et al (1975). However, it is possible to delineate some general factors that need to be considered when configuring such systems.

The following list of evaluation criteria, listed in order of decreasing significance, are suggested as a guide for selecting individual transducers and the associated acquisition equipment for environmental monitoring:

1. unattended operational reliability over environmental extremes,
2. low unit cost for transducers and transmission links,
3. battery powered operational capability,
4. early conversion of transducer outputs into a digital format,
5. prevention of time registration errors, and
6. compatibility with a variety of transducer outputs.

While the above list is given in a suggested priority order, individual circumstances certainly could change the relative position of one or more factors. Each entry needs further elaboration to allow it to be viewed in proper perspective.

Field sensors and acquisition equipment must operate over a wide range of adverse environmental conditions with only an occasional site visit to provide maintenance attention. Until problems of keeping a sizeable network of such field instrument operational have been experienced first-hand it is difficult to appreciate the importance of this selection criteria. Remote computer monitoring equipment is capable of detecting only gross failures; it cannot detect deterioration of calibration accuracy nor effect the repair of a nonfunctional sensor. Unfortunately, it is very difficult to evaluate the operational reliability of prospective components of a system. Some of the factors that merit consideration in making such an evaluation are: (1) quality of material and workmanship in the product; (2) design simplicity, especially for components utilizing electro-mechanical elements; (3) for sensors, the stability of the transducing relationship employed, i.e. the principle by which the variable being measured is converted into an electrical signal; (4) reputation of the manufacturer; and (5) if available, an evaluation of the experience of other users of the equipment. In configuring an installation one should always keep in mind that one of the most reliable means of assuring operational continuity is to include as much system redundancy as the budget will permit.

One of the major benefits of the drastic reduction in labor associated with automated acquisition systems is the capability to monitor a large number of transducers with little or no increase in operating costs. This offers the promise of increased utility from larger and broader data bases, i.e. monitoring more factors. However, this promise is obtainable only if the unit costs of the field transducers and components necessary to connect them to the acquisition system are relatively low. Obviously, compromise on this objective of low cost is sometimes necessary in order to obtain an adequate level of operational reliability.

Numerous examples could be given for applications of environmental monitoring at locations which require the equipment to be battery powered because line power is not economically available. However, even for installations where power is available, battery operation is often a significant or even essential feature. Several uses of environmental data require a continuous, long-term record of data. Even infrequent gaps due to short term power interruptions can be quite troublesome. Battery operation is especially important for systems on which the most critical data are collected during storm events when the probability of temporary power outage is highest. Various schemes are available to provide an uninterrupted power supply, but probably the simplest and most satisfactory is to acquire equipment with low power consumption which inherently uses batteries as its primary power source. If line power is readily available it can be used to continuously trickle charge the batteries; otherwise, solar, wind or water power can be used for charging batteries.

A majority of environmental transducers employ sensing elements which provide a continuous output (analog) proportional to the variable being monitored. However, available and foreseeable technologies to assure low cost, error free data transmission and storage require digital information. Therefore, it is generally desirable to provide for conversion of analog sensor outputs into a digital format as early as possible along the transmission route to the central processor.

Many uses for broadly based environmental data are more concerned with accurate relative times between two or more events than with their absolute time of occurrence. This is especially true when one is attempting to model processes such as non-point source pollution. For such applications the problem of time registration errors between independent recorders is very troublesome. This problem can readily be eliminated by using a central "recorder" with a single time base for all data. This is an inherent design characteristic of almost all automated systems and one of their important benefits.

The ability to accept "data" from transducers in more than one format can be a significant factor in the economic viability of an automatic data acquisition system. This flexibility is important in two regards: incorporation of existing transducers into a system and delay of system obsolescence. While almost all modern systems require an electronic data input, this can take the form of a voltage, current or frequency proportional to the monitored variable or of a switch closure which occurs after a preselected increment of change. The ability to accept a variety of these forms can significantly affect the feasibility of modifying an existing network of instruments to incorporate an automated acquisition capability. Similarily, this flexibility lengthens the useful life of the central unit because the probability is increased of being compatible with new transducers that might be added at a future date.

ALERT

The development of a system designed to accomplish the Acquisition of Local Environmentally Related Trends, ALERT, on the Black Creek project was intended to accomplish two primary objectives: (1) to automate the process of collecting hydrometeorological data from the Black Creek catchment in order to reduce data transcribing delay and labor while expanding the scope of the data collected and (2) to demonstrate a "real-time" acquisition system capable of providing a data base to permit hydrologic simulation of watershed responses concurrently with naturally occurring storm events. An integral part of the second objective involves using the computer to generate operational commands to control pumping samplers which collect water quality samples of the runoff. The availability of simultaneous data from a network of sensors dispersed over the watershed together with the predictive capabilities of the on-line computer are intended to improve the quality of these water samples. This improved quality is anticipated as the result of using short sampling intervals when pollution concentrations are likely to be changing rapidly and much slower sampling rates when conditions are stable. The rapid sampling rates make possible an accurate evaluation of total quantity of pollutants in the runoff while slow rates during stable conditions reduce the number of samples collected and the cost of subsequent laboratory analyses. While the ALERT system was designed to satisfy the objectives of a specific project, the requirements were of such a nature that the resulting system is directly applicable to a large percentage of environmental data acquisition applications.

One characteristic of environmental data which complicates the problem of automating its acquisition is the spatial variability of many of the factors of interest. This characteristic necessitates the installation of numerous sensors in widely dispersed patterns. Evaluation of several alternative transducer designs and transmission techniques resulted in the selection of a data encoding approach developed by Goodspeed and Savage (1969) and evaluated rigorously by Langham (1971). The concept was named the "incremental integral" approach by Langham, but is known more commonly as event recording. This approach involves recording the elapsed time required for each variable to change by a preselected increment in lieu of the level of each variable at selected time intervals.

The incremental integral concept can be implemented either by incorporating the principle in the design of individual transducers or by using a micro-processor to rapidly scan multiple sensors on a time interval basis and then output the corresponding event-type data. The former approach was chosen because such equipment, designed to operate on battery power, was commercially available.

Functionally, the output of a transducer designed to produce incremental integral data need be nothing more than a simple switch closure. These switch closures indicate to the central acquisition system that the monitored variable has changed by its preselected increment, i.e. an "event" corresponding to a known increment of change. The central acquisition system is required to note only the time at which this switch closure occurred. From such a data file the complete record of the variable's value as a function of time can be reconstructed. When numerous transducers, i.e. switch closures, are being monitored by a single central system each switch must be uniquely identified and simultaneous closures must be handled. This can readily be accomplished by numbering each switch (and then transmitting the switch's number to the central location) and by a priority arbitration scheme. Of course, transducers which monitor variables that are bidirectional, e.g. temperature, employ two switches, one to indicate a positive incremental change and a second to indicate a negative change.

The incremental integral concept provides four primary advantages for application to field data acquisition systems. Of greatest significance is the assurance of recording relatively high-frequency changes which might be missed with systems using the more common constant time interval sampling approach. This is especially useful because the rates of change of different environmental variables differ by orders of magnitude. Of course, the sampling interval of the classical approach can be made very short to reduce the probability of missing infrequent but rapid variations. However, the result of a short sampling interval is a high volume of redundant data and a corresponding increase in data storage, transmission and processing costs. Thus, the second advantage of the incremental integral approach is really a corollary of the first: elimination of collecting and storing redundant data. Thirdly, the incremental integral concept permits a compact data format, a single "character" switch number, which simplifies data transmission requirements and thereby reduces equipment costs. Finally, it is directly compatible with some existing environmental transducers, e.g. tipping bucket raingages and wind anemometers, and allows inexpensive adaptation of others, e.g. water stage, pan evaporation and wind direction.

The primary disadvantage of an incremental integral encoding approach is the stringent demands it places upon the data transmission linkages. Because it eliminates the transmission of redundant data characteristic of time interval sampling, the consequences of data "lost" due to bad transmissions are more serious. If the central acquisition system fails to detect that a switch closure has occurred it will continue to indicate an erronous value for that variable until a new "benchmark" value is reestablished. This benchmark must be reestablished either by the normal periodic site visits of qualified personnel or, if the field equipment is sufficiently sophisticated, by automatic retransmission of benchmark levels under command of the central computer.

The specific configuration of the ALERT system can best be described by reference to the block diagram of Figure 1. The remote sensor blocks actually correspond to dispersed locations within the catchment which are each capable of supporting multiple transducers and receiving control commands from the remote computer. Information is transmitted between the central receiver and the remote locations over a closed loop telephone link (solid lines in Figure 1) or battery-powered FM radio telemetry links. The choice between a telephone or radio transmission linkage is determined by the degree of availability of a telephone drop at a given remote site and the distance from the central receiver. The radio transmitters employed are limited to an 8 km radius.

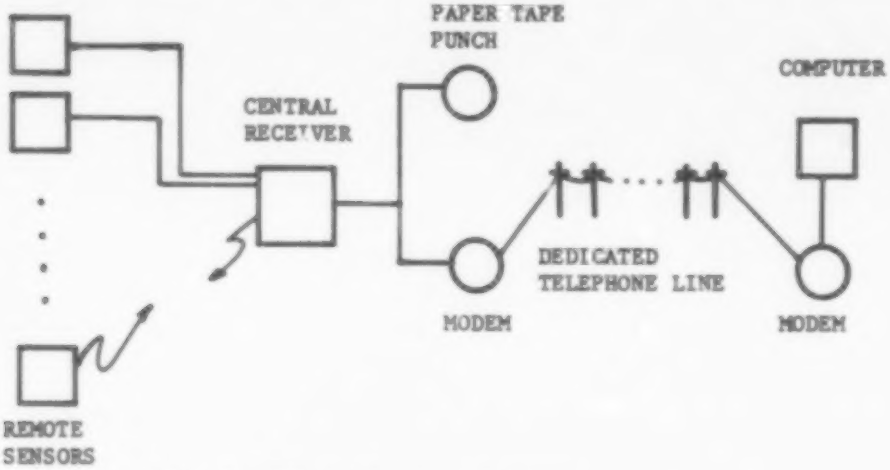

Fig. 1. Block diagram of ALERT system.

The transfer of information between the central receiver and the remote sites is controlled by electronics at the central receiver. The central "receiver" actually provides a complete two-way communication path and is continually transmitting control commands to the remote locations. These control commands are either instructions to operate instruments at the remote sites, e.g. the pumping water samplers, or polling instructions to synchronize the transfer of data from the various remote transducers to the central receiver. Upon receipt of its polling character an individual remote site will immediately transmit the switch number of any of its transducers which have detected their preselected increment of change.

Data from the remote transducers received by the central station is simultaneously transferred to two outputs. First, the data is presented to a battery operated paper tape punch which records a permanent record of the remote station number and its associated transducer switch number. Secondly, the site and switch number data are serialized and, through a modem* interface, transmitted over a dedicated telephone line to a remote on-line computer on the Purdue campus approximately 250 km away.

The on-site paper punch provides a back-up record and degree of redundancy essential to maintaining a continuous historical data file in the event of interrupted communication with the remote computer. Of course, any on-line, real-time analysis and control capability is lost during such conditions.

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*Modem is an acronym for modulator-demodulator. Operating in pairs, these devices provide a standard means of converting the voltage or currents generated and required by computers into tones suitable for transmission over telephone lines.

The on-line computer on the Purdue campus is a minicomputer running a time-sharing operating system designed to facilitate data acquisition and real-time control applications. The Black Creek installation is seen by the computer as simply one of several simultaneous users active on the system. The operating program which controls communication with the Black Creek station has four primary responsibilities: (1) assembling the incoming data into suitable files and permanent storage of these files on magnetic disk and/or tape, (2) maintenance of a dynamic file of the instantaneous level of all variables being monitored in the watershed and the operational status of all transducers, (3) providing a preliminary analysis of incoming data in order to issue feed-back control commands to operate the water sampling equipment, and (4) detection of storm conditions in the watershed that indicate the need to activate a complete real-time simulation of the hydrologic behavior of the catchment.

The distribution of data acquisition sites throughout the Black Creek watershed is shown on the map in Figure 2. Immediately adjacent to the central station, at location 6, which houses the central "receiver" electronics, paper tape punch and long-distance telephone interface, are those transducers monitoring parameters which exhibit little spatial variability: solar radiation, wind velocity and direction, humidity, pan evaporation, air temperature and barometric pressure. In addition, this site also has transducers for rainfall, soil temperature (10 cm bare soil), water stage on upper Black Creek and a pumping water sampler. Other remote locations monitor the variables as summarized in Table I.

Table 1. Remote Measurement Distribution

Station	Communication Link	Variables Monitored
2	Telephone	Stage, Soil Temperature Water Quality
3	Telephone	Stage, Rainfall
4	Telephone	Stage
8	Radio	Rainfall, Soil Temperature
9	Radio	Rainfall
10	Radio	Rainfall, Soil Temperature
12	Telephone	Stage, Rainfall, Water Quality

The ALERT system, in terms of the previously outlined subdivisions, would classify as a computer controlled system. However, in order to improve overall system reliability by the principle of redundancy, the concept of a stand-alone data logging system has also been included (via the punched paper tape system). The complete system was designed

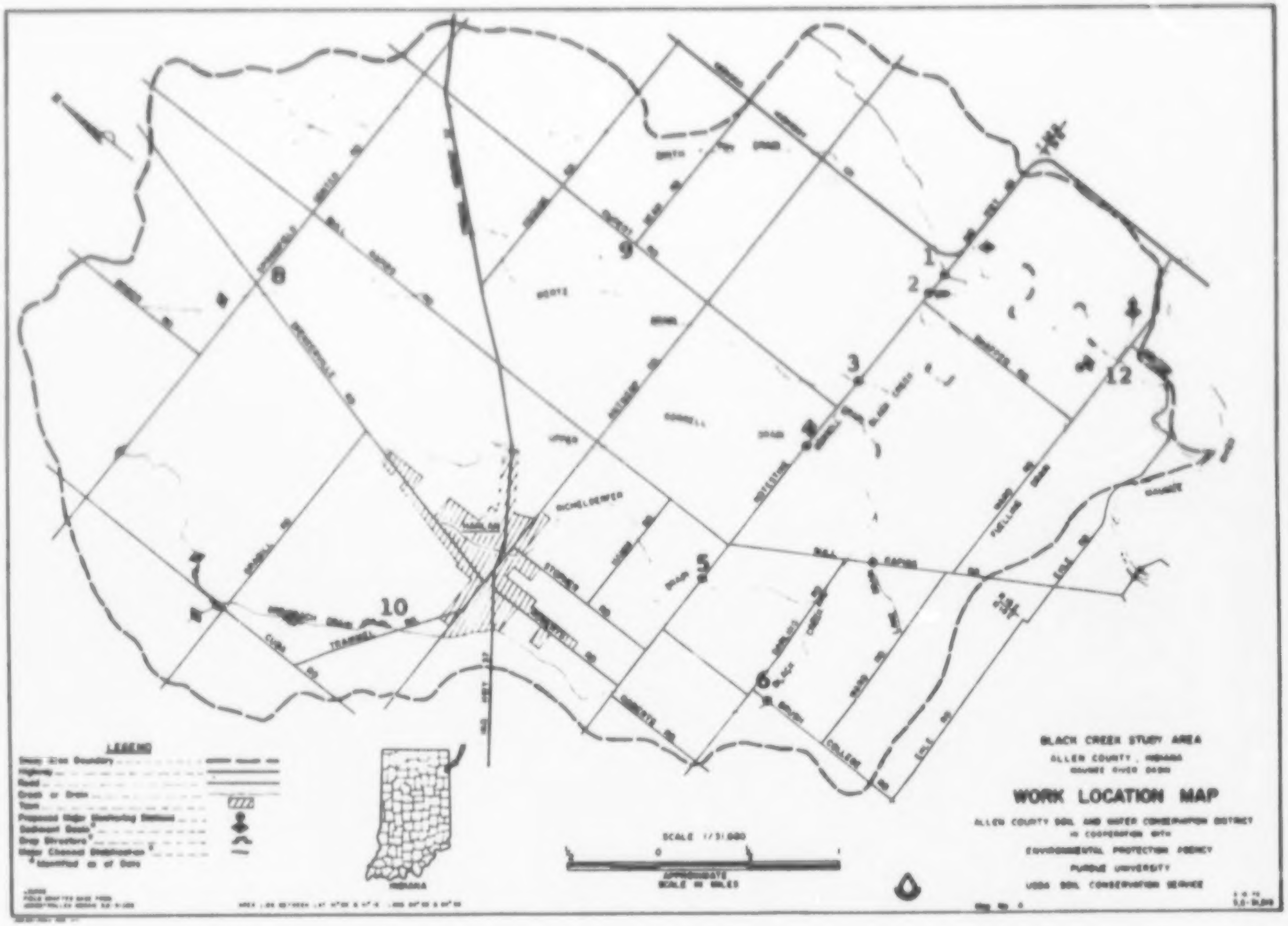

Fig. 2. Map of Black Creek Watershed showing remote transducer sitec.

with the requirement of on-line, real-time analysis capabilities as one of the major goals. The ultimate capabilities of such systems are entirely determined by the operating program installed in the remote computer. While the principle of event type data encoding was selected for the transducers, the actual hardware installed in the field does allow one to intermix transducers using a time interval sampling approach. Furthermore, the interfacing hardware and data transmission scheme were deliberately selected to permit the use of any time-sharing computer system that provides a goal of 24-hour service.

SUMMARY

General trends in the area of automating the acquisition of environmental data were reviewed. Because of the rapidly developing technologies of micro-processors and low-power integrated circuits it was concluded that we are on the threshold of rapid and fundamental change in the methodologies that are economically feasible. The implications of these changes and the factors which need consideration as one becomes involved in this transition were outlined. Finally, a specific example of one very general purpose system, ALERT, currently being activated on the Black Creek watershed was discussed in terms of its design philosophy and functional characteristics.

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PROJECT MANAGEMENT AND LAND TREATMENT COSTS

by

James E. Lake[1]

ABSTRACT

The Black Creek sediment control study, an Environmental Protection Agency-funded project to determine the environmental impact of land use on water quality is finishing its second year of activities. The project, which is directed by the Allen County Soil and Water Conservation District, is an attempt to determine the role that agricultural pollutants play in the degradation of water quality in the Maumee River Basin and ultimately in Lake Erie.

The Black Creek project was designed and developed by a consortium of the Environmental Protection Agency, the Soil Conservation Service of the United States Department of Agriculture, Purdue University, and the Allen County District. It is a response to allegations, first brought to the attention of Allen County residents at a Conference on the future of the Maumee River sponsored by Rep. J. Edward Roush in January of 1972.

At the conference, sediments and related pollutants were named as major contributors to the degradation of water quality in Lake Erie. It was further suggested that agricultural operations significantly increased the amount of sediment and sediment related pollutants.

The Black Creek Sediment Study, funded by a grant of nearly $2 million, is an attempt to discover the role that agricultural operations play in the pollution of the Maumee River and how that role can be diminished through the application of significant land treatment practices.

The project represents a multi-agency, multi-discipline approach to the total problem of non-point source pollution. It involves demonstration, through a program of accelerated land treatment with the assistance of the Soil Conservation Service, applied research by Purdue University, administration by the Allen County Soil and Water Conservation District, and cooperation from a variety of state, federal, and local agencies.

MANAGEMENT

The Black Creek Project being conducted by the Allen County Soil and

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[1] Allen County Conservationist in charge of directing the "Black Creek Study" Environmental Impact of Land Use on Water Quality for the Allen County Soil and Water Conservation District.

Water Conservation District to study the Environmental Impact of Land Use on Water Quality was the first project of its kind in the nation. However several other projects like it have been started since the Black Creek project was initiated in October 1972. The project came about due to the need to gain more information about non-point pollution in the Maumee River basin. This need surfaced as the result of a conference sponsored by U.S. Congressman J. Edward Roush in January 1972 to discuss the condition of the Maumee River non-point pollution was labeled as the major contributor to the rivers degradation, with sediment being the worst single pollutant. The information that came about at this seminar lead the district to be strongly concerned and eventually lead to the districts request for a demonstration grant from the U.S. Environmental Protection Agency.

Funding for the Black Creek Project was obtained through the U.S. Environmental Protection Agency, Grants Administration Branch, under Demonstration Project - Section 108. The project is estimated to cost a total of $2.5 million dollars with approximately $2 million dollars being received from the grant. The balance of the money is generated locally from various sources. The district signed a contract and received the grant from the Environmental Protection Agency in October 1972. EPA has made a committment of the total dollars estimated as well as the complete time period originally planned. The grant however is regulated such that funds are received by the district only on a reimburseable basis. In other words the district submits vouchers to the Environmental Protection Agency on a quarterly basis showing the total expenditures made during the quarter. EPA then reimburses the district 75% of their total cost. An initial advance however was awarded to the district in order to have some operating funds. All correspondence and memos pertaining to the contract between the district and the U.S. Environmental Protection Agency are handled between Carl Wilson, the EPA Project Officer for the Black Creek Study and myself. Using the money that the district has been awarded by the U.S. EPA, the district in turn has sub-contracted with both the U.S. Soil Conservation Service and Purdue University. The sub-contract with the Soil Conservation Service is for the purpose of receiving from them technical assistance for planning and application in the watershed area.

The contract with SCS encompasses approximately $197,000 dollars which the district is using to reimburse the Soil Conservation Service for placing additional Soil Conservationist and Soil Conservation Technicians in the project office to assist in the accelerated planning and application program. During some time of the sub-contract period calls for more than one man-year of additional soil conservation assistance. For example in a period of October 1972 through October 1975, 1.8 man-years of Soil Conservationist assistance is provided in the contract. At the present time the Soil Conservation Service has exceeded that agreement and provided the project with two Soil Conservationist, full time in the project area. During this same period of time the contract calls for 1.1 man-years of Soil Conservation Technician assistance. At the present time we have only a part time technician, but the balance of the man hours are received from area engineering staff. On occasion we receive assistance from the State Office staff. The thing that is unique about the Black Creek project and the district's relation with the Soil Conservation Service is that the district is directing the program. In this project, the Soil Conservation Service is truly assisting the district, not the reverse. For example, due to the excellerated land treatment program needed in the Black Creek area a special technical guide for standards in applying practices was developed. The normal soil conservation standards and specifications have been altered in a few cases by the district for the needs of the Black Creek project. During the course of the project activity the district has found need from time to time to make further changes in standards and specifications. The district has also been in the position to direct the type of work to be done, the priority for getting it done, as well as who will do it. The experience gained by the district through this project and especially through the sub-contract between the Soil Conservation Service and the district has been a real learning experience for the district and is an opportunity that other districts should make every effort to seek.

The district has also used grant funds to enter a sub-contract with Purdue University Research Foundation to obtain the services of Purdue University in monitoring and evaluating the land use activities as they relate to water quality in the watershed area. With the recent increase in the sub-contract as the result of Dr. Larry Huggins program for real time meteorological monitoring in the project area. The total sub-contract with Purdue is $1,181,000 million dollars for the total project period. The district has to rely heavily on the expertice of the Purdue specialists to monitor and evaluate watershed activities. The district officials have very little knowledge about monitoring activities, therefore are not in the position to scrutinize Purdue's activities as closely as the activities of the Soil Conservation Service. The district has and does, however make recommendations as to the general areas that should be monitored, specific sites to be used as collecting points, and have had a great deal to say about the timing of the monitoring activities.

Due to the financial aspect of the sub-contracts between Purdue and the district, many of the district's suggestions are abided by. The guidelines the district uses for directing both the sub-contractors (SCS and Purdue) are the original Plan of Work, entitled "Environmental Impact of Land Use on Water Quality", dated May 1973, and the "Operations Manual" EPA document #905-74-002 dated August 1973. Due to the complexity of the project and the district's role with the U.S. Environmental Protection Agency as well as both sub-contractors the district has been placed in a position where it had to "grow-up" to meet the challenge, and it has met the challenge gallantly.

In addition to the two major sub-contracts the district has an agreement with the Allen County Data Processing Agency to program all dollar expenditures and dollar committments as well as print all of the district's checks for payment. This service has been a real asset to the proper financial management of the Black Creek Project. A sample of a computer generated print-out of the Black Creek financial status has been attached as an appendix to illustrate the service being provided by Allen County Data Processing. This service is almost essential in order to know the long range financial committments and balances in order to program the funds for the entire project period. In addition to all these contractual agreements the district has "Memorandum of Understandings" with several state organizations including: The Department of Natural Resources, State Soil and Water Conservation District Committee, State Highway Department, State Board of Accounts and several others.

We also have Memorandums of Agreements and working relations with the Allen County Surveyor's office, Allen County Plan Commission, and of course the Allen County Council and Allen County Commissioners who provide local funding to the district. In addition to working with all these agencies and departments the district has the obligation to assist the private landowners who live in the Black Creek watershed. After all if we cannot communicate and work with private landowners, then all the agencies and department's assistance is of little value. Therefore the most important attribute of the district program is that they have the local "grass roots" contact with the private landowner. The private landowner is in tune with and has confidence in his local district official. It is through the local district officials that federal agencies are able to carry out their objectives which is the case in the Black Creek Project. As a district we enjoy the challenge and we maintain that we are the only agency of government that can work with so many other agencies as well as private landowners and bring them all together like the "spokes of a wheel" and come out with successful unified program approach. See figure 9.1 for organization of project personnel.

FINANCIAL MANAGEMENT

Overall Costs Versus Budget

As I previously mentioned, the Black Creek Project was estimated to cost $2.5 million dollars of which $2 million would be received from the U.S. Environmental Protection Agency with a twenty-five percent match required from the local sources. As with everything else, costs have been consistantly higher than was previously expected. However, we have managed to conduct the study to date within the originally allocated budget as can be seen on figure 9.2.* Several internal transfers of money have been necessary, however to do so. For example, money had to be taken (with permission from the EPA Project Officer) from supplies appropriation and placed in the equipment appropriation to cover the higher than anticipated equipment costs of both the district and Purdue budgets. All the money was appropriated based on a yearly estimate and it has been necessary at times to transfer money from one year to another in order to cover expenditures.

In looking closely at figure 9.2, one can see that expenditures were not as high in the early stages of the project as was expected but were higher than expected the second year. In order to revise the budget for 1974 and 1975, money was taken from the appropriations for 1972 and 1973. The one budget that was most seriously underestimated was that of the district. As can be seen in figure 9.3,* only $22,000 was appropriated for the entire district project costs. It was soon recognized that the staff placed in the project office was not adequate to meet the demands of the project. Personnel from the Soil Conservation Service were not adequate to handle the increased number of landowner requests and engineering requirements generated from this accelerated land treatment program.

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*Taken from Environmental Impact of Land Use on Water Quality - progress report EPA 905/9-75-006, dated November 1975.

ORGANIZATION
of
PROJECT PERSONNEL

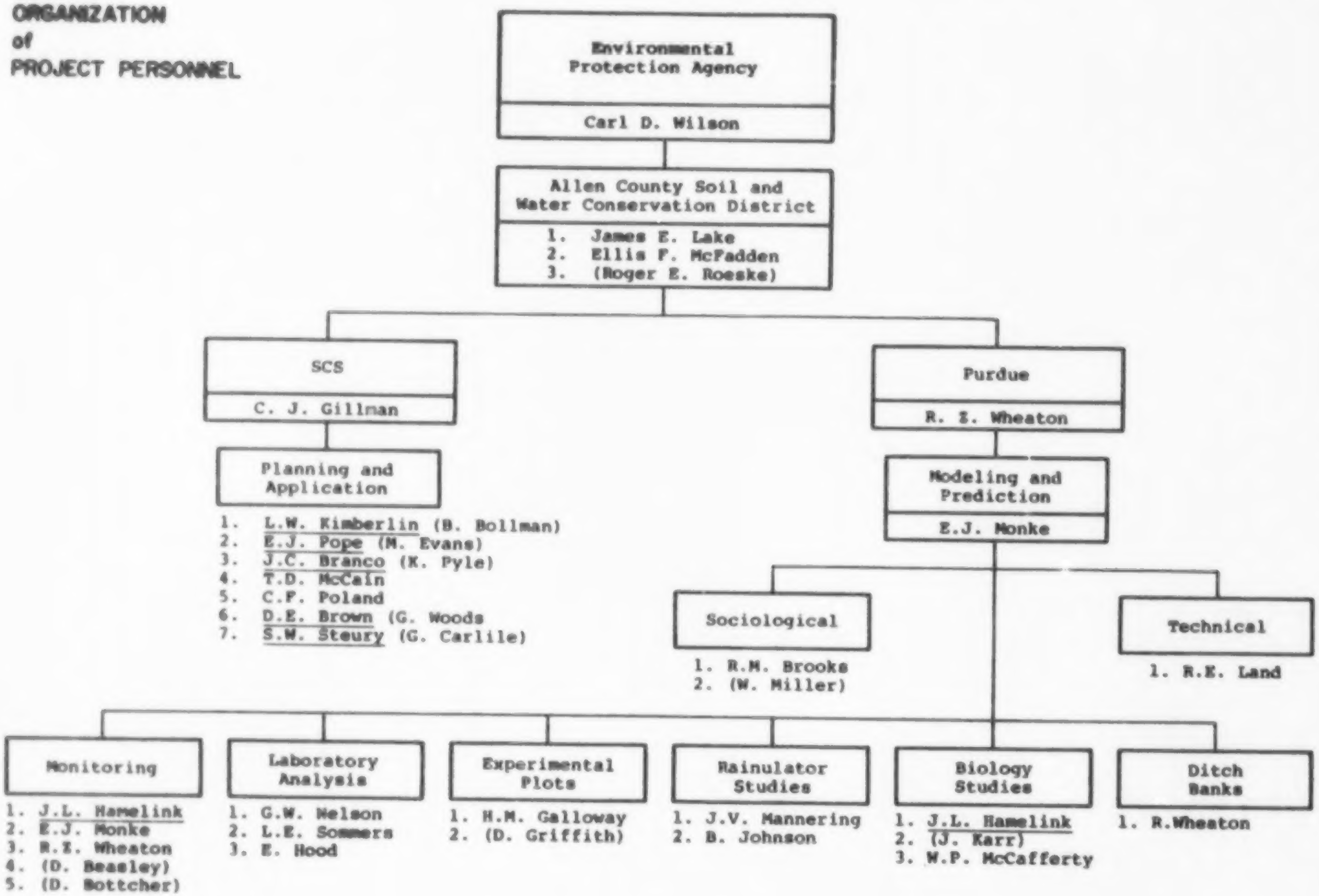

Figure 9.1 Organization of Project Personnel

Rather than attempt to re-finance in order to place more Soil Conservation personnel in the project office, it was decided by the District Board of Supervisors to hire our own additional staff to meet the demands. Thefefore, money was transferred from the land treatment portion of the project to the district budget in order that the district could hire a professional engineer of their own. This revised increased cost is reflected in figure 9.3. The district board felt that this was a sound expenditure in that there would be no delays in getting the man placed in the project office and that there would be no further problems such as transfers, and relocations, etc. By hiring its own employee, the district felt it would have more control of the operations at the project office level through the duration of the project. As can be seen in figure 9.4* and 9.5*, both Purdue and the Soil Conservation Service were able to keep project expenditures within the original appropriation. The only minor changes in the budgeting for these sub-contracts were a few transfers of money from the early years of the project to later years in the project.

Land Treatment Goals Versus Accomplishments Versus Expenditures

The most important aspect of the entire Black Creek Project is the application of practices on private land in order to monitor the affects of land treatment on water quality. A total of $750,000 was committed to land treatment activities. These funds were to be used as cost-share incentives to landowners for the installation of needed land treatment practices. This amount was approved by careful thought by a team from the Soil Conservation Service and the district which studied the entire Black Creek watershed area during the development of the work plan and set up goals for each of 34 different conservation practices identified as needed in the Black Creek area. These goals were based on soil types, land capability units, and the agricultural land uses that existed in the watershed at the beginning of the project. These goals were based on 100 percent land treatment accomplishments over the entire watershed area. Average unit costs were established for each practice, and a budget was set up for each practice based on the goal times the unit cost. See table A-10 which was inserted from the original work plan, Environmental Impact of Land Use on Water Quality, dated May 1973. The total goal for land treatment times the unit cost for these practices is a little over $1 million. Since it was decided it would cost at least $1 million for total land treatment in the watershed area, and the district determined that it would like its average cost-share incentive to the landowners to be 75 percent of total cost, a figure of $750,000 was placed in the budget for cost-sharing to private landowners for land treatment. We also realized that 100 percent land treatment was not practical to obtain, therefore, we felt that $750,000 would be more than adequate.

In reviewing table A-10 which outlined the land treatment goals and estimated installation costs one must realize the amount of effort and thought that went into the development of this table. In order to arrive at the budget for land treatment the district and SCS had to carefully scrutinize what practices were applicable in the Black Creek watershed

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*Taken from Environmental Impact of Land Use on Water Quality - progress report EPA 905/9-75-006, dated November 1975.

TABLE A-10 - BLACK CREEK STUDY

Maumee River Basin

Land Treatment Goals & Estimated Installation Costs

					YEARLY GOALS AND BY UNIT INSTALLATION COSTS (DOLLARS)									
					Oct.72-Oct.73		Oct.73-Oct.74		Oct.74-Oct.75		Oct.75-Oct.76		Oct.76-Oct.77	
ITEM	UNIT	GOAL	UNIT PRICE $	TOTAL COST	GOAL	COST	GOAL	COST	GOAL	COST	GOAL	COST	GOAL	COST
Land Adequately Treated	Ac.	10,573			671		2,612		3,533		3,757			
Cropland to Grassland	Ac.	4					4							
Cropland to Woodland	Ac.	10							10					
Cropland to Wildlife & Rec.	Ac.	94					20		29		45			
Cropland to Other	Ac.	35					8		11		16			
District Cooperators	No.	148			40		60		29		19			
District Cooperators	Ac.	7,747			2,094		3,141		1,536		977			
Conservation Plans	No.	170			16		53		57		44			
Conservation Plans	Ac.	10,641			1,002		3,317		3,589		2,733			
Conservation Plans Revised	No.	6			3		3							
Conservation Plans Revised	Ac.	1,040			520		520							
Conservation Cropping System	Ac.	7,418	1.50	11,127	600	900	1,978	2,967	2,637	3,955	2,203	3,305		
Contour Farming	Ac.	769	2.00	1,538	-	-	205	410	273	546	291	582		
Critical Area Planting	Ac.	10	400.00	4,000	1	400	2	800	4	1,600	3	1,200		
Crop Residue Management	Ac.	7,491	1.50	11,236	600	900	1,997	2,995	2,663	3,995	2,231	3,346		
Diversions	Ft.	39,200	0.50	19,600	2,600	1,300	10,000	5,000	13,500	6,750	13,100	6,550		
Farmstead & Feedlot Windbreaks	Ac.	75	80.00	6,000	-	-	21	1,680	28	2,240	26	2,080		
Field Border	Ft.	288,320	0.30	86,496	25,000	7,500	51,866	15,560	102,488	30,747	108,966	32,689		
Field Windbreak	Ft.	12,000	0.05	600	-	-	3,199	160	4,265	213	4,536	227		
Grade Stabilization Structures	No.	368	500.00	184,000	30	15,000	88	44,000	117	58,500	133	66,500		
Grassed Waterway or Outlet	Ac.	68	450.00	30,600	9	4,050	18	8,100	24	10,800	17	7,650		
Holding Ponds & Tanks	No.	11	5,600.00	61,600	1	5,600	2	11,200	4	22,400	4	22,400		
Land Smoothing	Ac.	300	75.00	22,500	-	-	80	6,000	107	8,025	113	8,475		
Livestock Exclusion	Ac.	215	20.00	4,300	20	400	47	940	66	1,320	82	1,640		
Livestock Watering Facility	No.	28	200.00	5,600	2	400	5	1,000	9	1,800	12	2,400		
Minimum Tillage	Ac.	7,656	6.50	49,764	300	1,950	2,041	13,266	2,722	17,694	2,593	16,854		
Pasture & Hayland Management	Ac	402	18.00	7,236	20	360	87	1,566	143	2,574	152	2,736		
Pasture & Hayland Planting	Ac.	501	70.00	35,070	50	3,500	124	8,680	165	11,550	162	11,340		
Pond	No.	39	2,500.00	97,500	2	5,000	8	20,000	14	35,000	15	37,500		
Protection During Development		118	100.00	11,800	3	300	28	2,800	42	4,200	45	4,500		
Recreation Area Improvement	Ac.	12	200.00	2,400	-	-	3	600	4	800	5	1,000		
Sediment Control Basin	No.	6	5,000.00	30,000	6	30,000					-	-		
1/ Stream Channel Stabilization	Ft.	90,000	0.50	45,0[illegible]	3,000	1,500	23,594	11,797	31,458	15,729	31,948	15,974		
2/ Stream Channel Stabilization	Ft.	6,000	6.00	36,0[illegible]	-	-	2,000	12,000	2,000	12,000	2,000	12,000		
Streambank Protection	Ft.	122,000	2.00	244,000	10,000	20,000	32,525	65,050	43,365	86,730	36,110	72,220		
Stripcropping	Ac.	300	5.00	1,500	-	-	80	400	105	525	115	575		
Surface Drains	Ft.	90,500	0.40	36,200	3,000	1,200	24,127	9,651	32,170	12,868	31,203	12,481		
Terraces, Gradient	Ft.	11,000	0.25	2,750	-	-	2,933	733	3,910	978	4,157	1,039		
Terraces, Parallel	Ft.	11,000	0.75	8,250	-	-	2,933	2,200	3,911	2,933	4,156	3,117		
3/ Tile Drains	Ft.	200,300	0.40	80,120	16,068	6,427	50,360	20,144	68,360	27,344	65,512	26,205		
Tree Planting	Ac.	10	80.00	800	-	-	3	240	4	320	3	240		
Wildlife Habitat Management	Ac.	222	70.00	15,540	-	-	59	4,130	79	5,530	84	5,880		
Woodland Improved Harvesting	Ac.	200	15.00	3,000	20	300	40	600	74	1,110	66	990		
Woodland Improvement	Ac.	610	20.00	12,200	20	400	143	2,860	217	4,340	230	4,600		
Woodland Pruning	Ac.	50	30.00	1,500	10	300	10	300	13	390	17	510		
SUBTOTAL				1,169,827		107,687		277,829		395,506		388,805		
TECHNICAL ASSISTANCE (SCS)				197,364		46,500 4/		36,843		55,291		45,705	-	13,025
TOTAL INSTALLATION COSTS				1,367,191		154,187		314,672		450,797		434,510	-	13,025

1/ Fence to exclude livestock; 2/ Structural protection; 3/ Quantity shown includes only tile under grassed waterways and surface drains; 4/ Includes cost associated with preparation of detailed work plan.

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and then estimate the amount of each practice that was needed for total land treatment. Once this task was completed, a unit price had to be established for each identified practice. In order to do so we had to rely on our past experience as to what it costs to install the practice, and in some cases, had to apply an educated guess for those practices which had very little information about costs. At this point in time we can say that we were quite successful in applying unit prices to the 34 practices listed in table A-10. There were a few practices however, that we set our unit costs too low. One example is Farmstead and Feedlot Windbreaks in which we set the unit price at $80 per acre and we have since then changed to $330 per acre as a result of action by the board of supervisors. We also used an estimated unit price of $500 per Grade Stabilization Structure and found out later that structures depending on the type and size can range from $150 to $1500 per installation. We estimated that Stream Channel Stabilization which is the placement of rip-rap stone for erosion protection along streambanks would take approximately one ton of stone per foot for adequate protection. The stone has cost us anywhere from $8 to $10 a ton placed, therefore making the cost $8 to $10 per foot. We estimated the unit price for Minimum Tillage application in the watershed to be $6.50 per acre and we have been rather unsuccessful in getting large amounts of minimum tillage applied to meet the Black Creek standards and specifications. Recently the board had adopted a new unit cost of $7 per acre. We may find that this price is not high enough. In considering the cost of tile drains which would accompany various erosion control practices, we estimated that the installation cost to be approximately 40¢ per foot. This unit cost is adequate for four inch drainage tile, however when constructing large Grass Waterways, large Terrace systems or extension Surface Drainage or Diversions, four inch tile are not adequate for the drainage area entering it. Therefore larger tile sizes are needed, and as a result increased cost per foot. Since the time of the development of table A-10 we have set a new unit price for tile drainage based on the size of tile recommended by the Soil Conservation Service. We do restrict tile drainage cost-sharing to only those tile drains that are associated with an erosion control practice. In order to update table A-10 and to give the reader a feeling for the local policy making control obtained by the district on this project, I have inserted table 2.1* which shows various practice specifications and cost-sharing changes which have been adopted by the board of supervisors during the duration of the project to date. It is very beneficial that the district has the control to be able to adjust and change practice specifications and cost-sharing to meet the needs of the local watershed project. If the practice and cost-sharing rates were ridgid and not subject to change many difficulties would have been created by some of the original estimates included on table A-10. This reiterates the need for keeping a program which involves dealing with private landowners in the hands of local administration.

Figures 9.6* through 9.38 illustrate the goals by year, the planned committment for application, the total accomplishments to date (bar graph) and an original cost-share funds appropriated for each practice. In analyzing these figures it is obvious that in most cases the goal is significantly higher than committments or accomplishments. There are a few cases, (see Grade Stabilization Structures, figure 9.14, Stream Channel Stabilization, figure 9.28) where the accomplishments and expenditures exceed the original estimate. This is very gratifying. These two practices were installed at a faster rate than originally expected. Other practices that have been applied at very high levels are Conservation Cropping System (figure 9.6), Critical Area Planting (figure 9.10), Field Borders (figure 9.12), Grassed Waterway (figure 9.13). Even with the accelerated application of these practices, 100 percent of the goal has not been reached on any of them. This indicates that either the goals were originally set too high or that there is more required to obtain concentrated land treatment than providing technical assistance and cost-sharing assistance.

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*Taken from Environmental Impact of Land Use on Water Quality - progress report EPA 905/9-75-006, dated November 1975.

Several practice accomplishments have been quite discouraging, such as Contour Farming (figure 9.7), Farmstead and Feedlot Windbreak (figure 9.11), Field Windbreak (figure 9.13), Land Smoothing (figure 9.17), Minimum Tillage (figure 9.20), Pasture and Hayland Planting (figure 9.22), Sediment Control Basin (figure 9.26), Strip Cropping (figure 9.30), Tree Planting (figure 9.33) and Woodland Practices (figure 9.35 and 9.37).

Some of these practices are apparently not very adaptable to the Black Creek watershed area. Farmers have been very reluctant to accept these practices even with high levels of cost-sharing incentives.

One practice of great concern is Minimum Tillage. Minimum tillage is frequently cited as a key practice for lowering erosion in the Maumee Basin area. Even though minimum tillage sounds like a very promising erosion control technique, it has not been readily accepted by farmers in the watershed area. There has not been sufficient research and demonstration on minimum tillage in the heavy lake bed soils to encourage and educate the farmer to attempt to using it. When farmers are convinced that minimum tillage will not reduce yields and lower their income potential, they will be willing to adapt the practice. If farmers can be shown that minimum tillage will save them money, as well as soil it will be readily accepted basin wide.

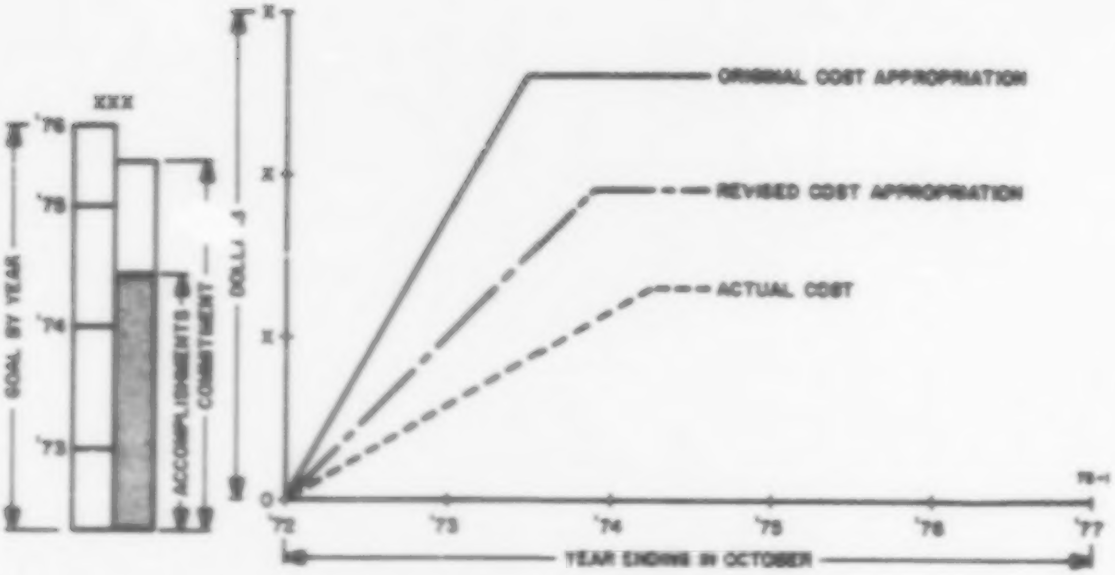
It has often been said that if funds were made available at a level high enough to insure the farmer sufficient levels of cost-sharing assistance, many practices which have been encouraged by the Soil Conservation Service for years would be installed rapidly. We are learning from the Black Creek project that even when high levels of funding are provided to farmers for proper installation of conservation practices, there is one other factor more important then money. This is the decision by the private landowner as to the suitability of practice on his farm. If the farmer is not willing to install the practices because he cannot see any value in applying certain practices, no level of funding will be sufficient to encourage application of them. Planning, technical assistance, and adequate financial cost-sharing have little value without the decision of the private landowner to install the practices needed. This leaves the question as to how to get the landowners to make the decision to install needed conservation practices. We hope that this project might give us insights to this question.

Practice	Spec. Change	Cost-Share Change	The Change Is	Reason
Conservation Cropping System	Yes	No	Change to pay only on farms where a change in rotation is made.	This was a give-away to landowner on flat land that required no changes to meet specifications.
Crop Residue Management	Yes	Yes	Change to pay only on farms where a change in rotation is made. 70% of $1.50/ac. to 80% of $1.50/ac.	To make a little more incentive and to stop give aways for no change.
Diversion	No	Yes	Reduce inlet cost-share for $150.00 each to $50.00 each.	This puts cost of tile back on the tile practice specifications and cost-share.
Farmstead and Feedlot Windbreak	No	Yes	Increase from $80.00/ac. to $300.00/ac.	Incentive to buy larger trees.
Grassed Waterway	No	Yes	To include payment on a cubic yard or lineal foot basis.	Make excavation costs easier and faster.
Minimum Tillage	Yes	Yes	Increase base rate to $7.00 /ac. Have three options: 80%, 65%, 30%.	Incentives to get more minimum tillage.
Pasture Planting	No	Yes	Price unit from $70.00/ac. to $100.00/ac.	More incentive to plant permanent pasture.
Pond	No	Yes	Increase cost-share on seeding to 80% of $75.00/ac. Increase seed and mulch to 80% of $150.00/ac.	Make rates uniform with other seeding practices.

Table 2.1 Changes in Practices Specifications and Cost-Share

Practice	Spec. Change	Cost-Share Change	The Change Is	Reason
Strip Cropping	Yes	No	Make payments on consecutive years on same area.	More incentives to apply practice.
Terraces-Gradient	No	Yes	Reduce inlet cost-share for $150.00 each to $50.00 each.	This puts cost of tile back on the tile practice specifications and cost-share.
Terraces-Parallel	No	Yes	Reduce inlet cost-share for $150.00 each to $50.00 each.	This puts cost of tile back on the tile practice specifications and cost-share.
FOLLOWING CHANGES EFFECTIVE JULY 14, 1975				
Grassed Waterway	No	Yes	Increase cost-share to 90%	Added incentive for more waterways.
Pasture Management	No	Yes	Increase cost-share from 65% of $18.00/ac. to 65% of $50.00/ac.	Added incentive and help to cover cost of increased fertiliser and lime.
Pond	Yes	Yes	Allow construction of ½ ac. livestock ponds and pay 75%. Also remove $1800.00 hold down on other ponds and pay maximum of 60% of estimate.	Incentive for more ponds.
Contour Strip Cropping	No	Yes	Increase unit price from $5.00 per acre to $10.00 per acre.	Incentive for more of the practice.
Terraces	No	Yes	Increase cost-share to 90%	Incentive for more of the practice.
Fencing	Yes	No	Change specification to allow 1 barb on woven wire or 4 barbed wire fence.	To make a more workable specification.

Practice	Spec. Change	Cost-Share Change	The Change Is	Reason
Field Border	No	Yes	Reduce cost-share from 70% to 60%	Make payments to end of project more equitable.
Diversions	No	Yes	Increase cost-share to 90%	Incentive for more of the practice.
Livestock Exclusion	Yes	Yes	Start paying for excluding livestock from woods. Pay 70% of $4.00 per acre.	Encourage landowners to keep livestock out of woods.



KEY TO FIGURE 9.2 THROUGH 9.38

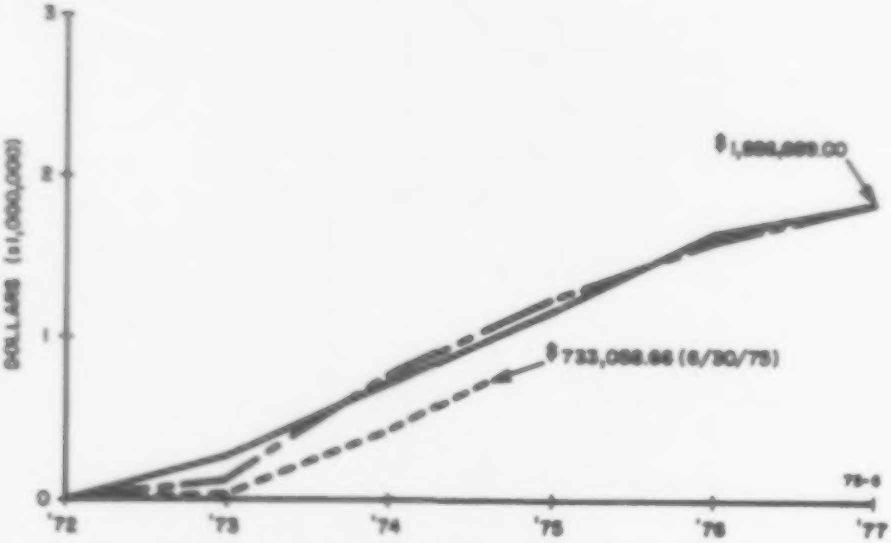


Figure 9.2 Project Appropriations and Expenditures

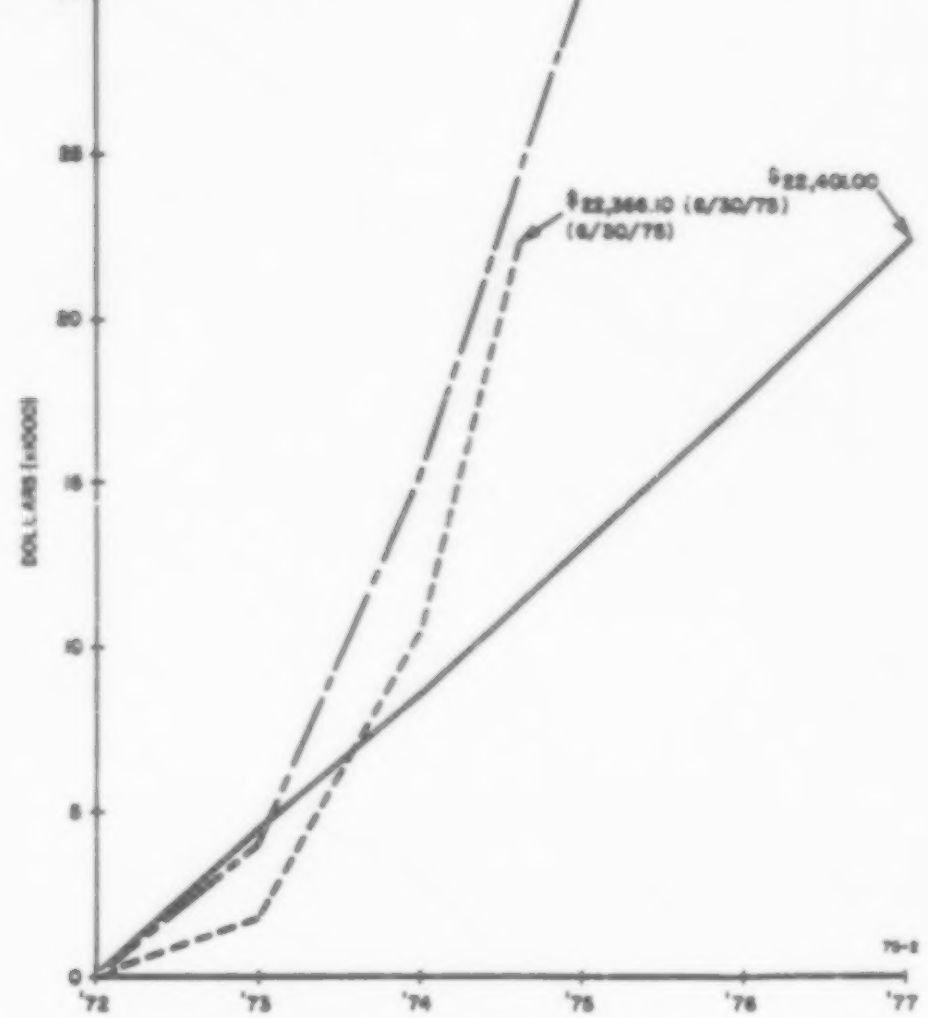


Figure 9.3 District Appropriations and Expenditures

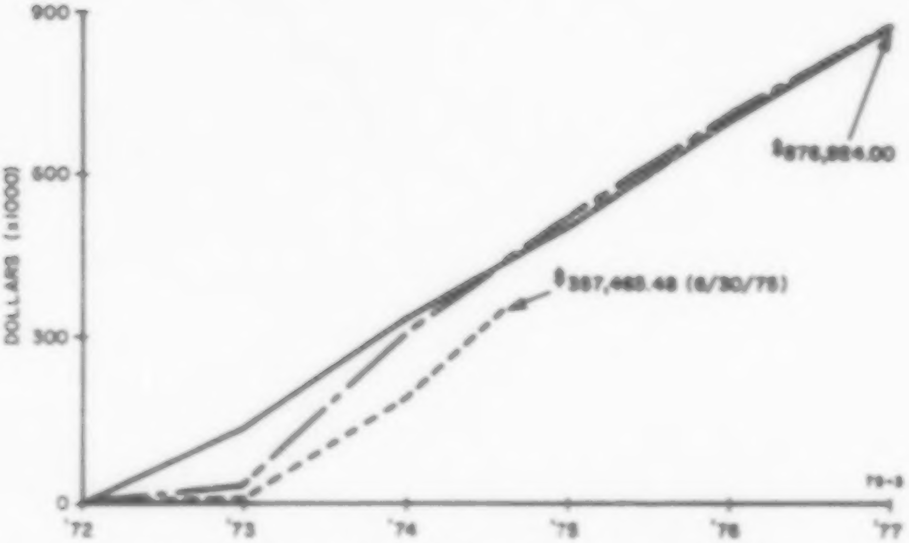


Figure 9.4 Purdue Appropriations and Expenditures

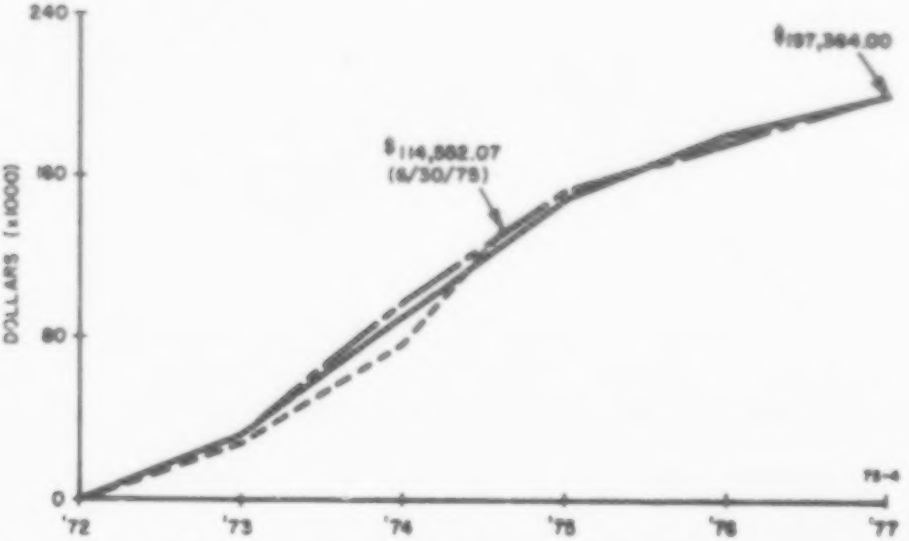


Figure 9.5 Soil Conservation Service Appropriations and Expenditures

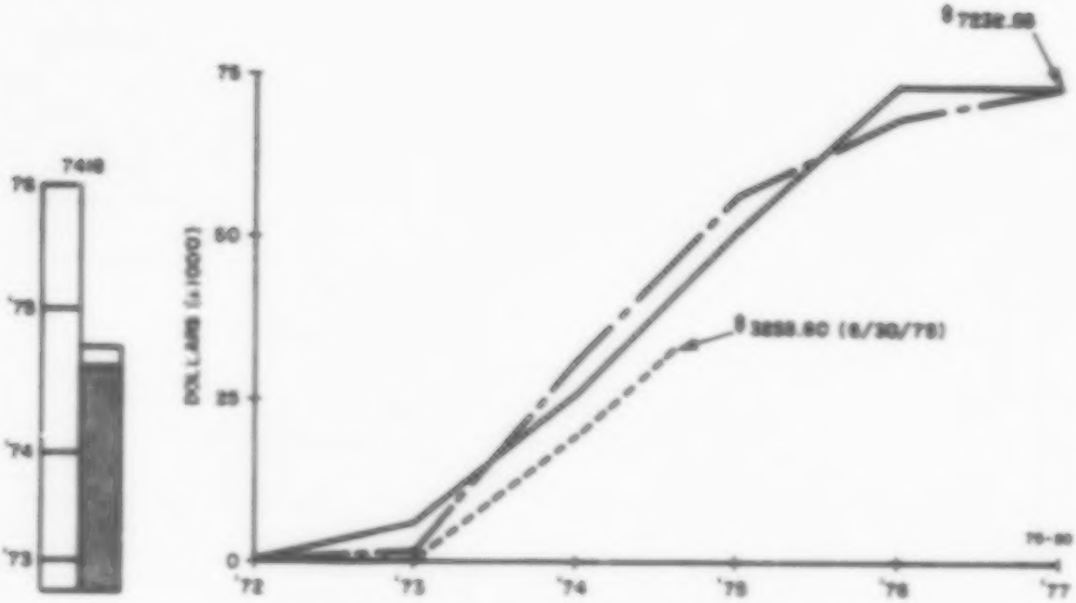


Figure 9.6 Conservation Cropping System

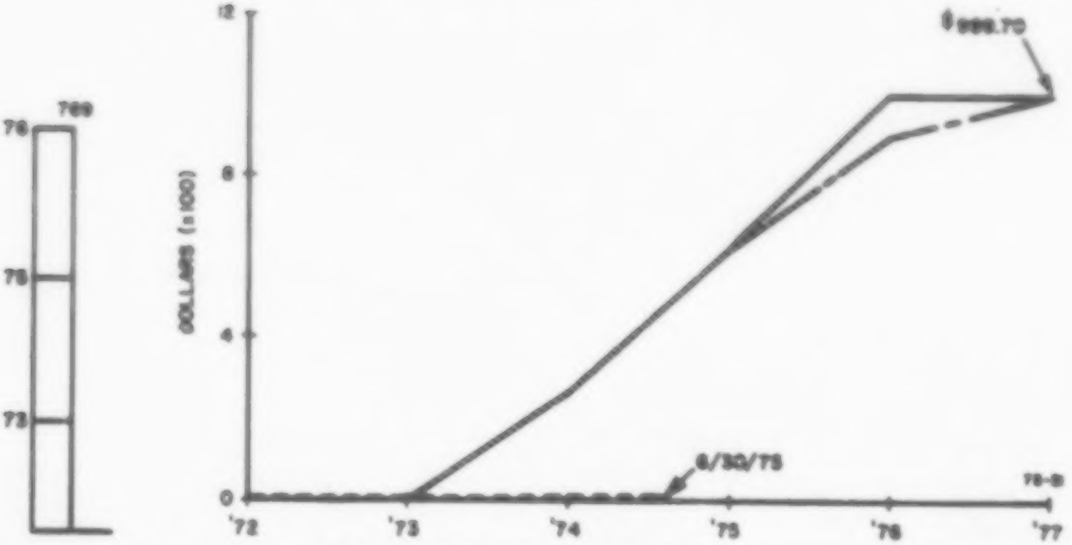


Figure 9.7 Contour Farming

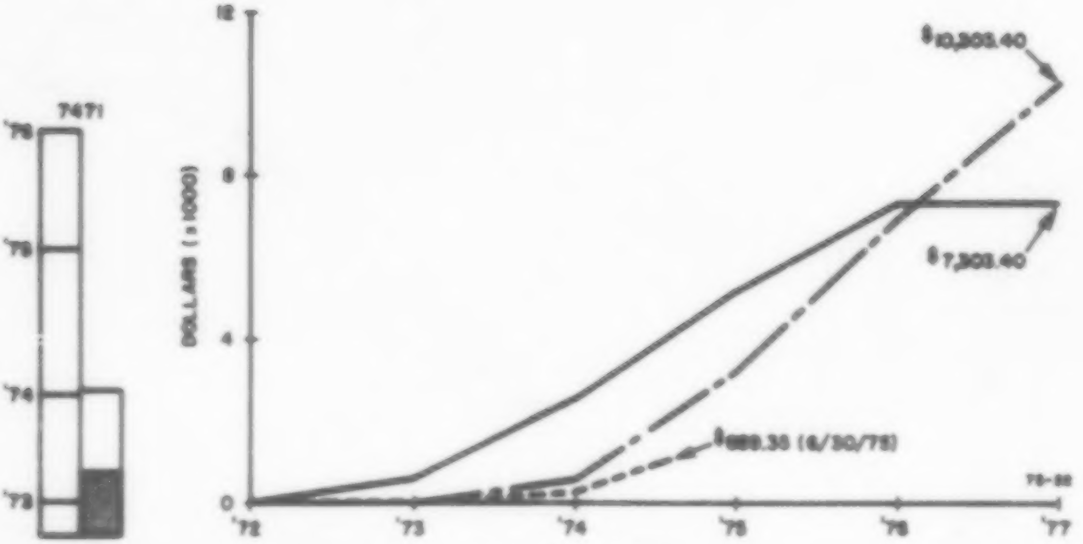


Figure 9.8 Crop Residue Management

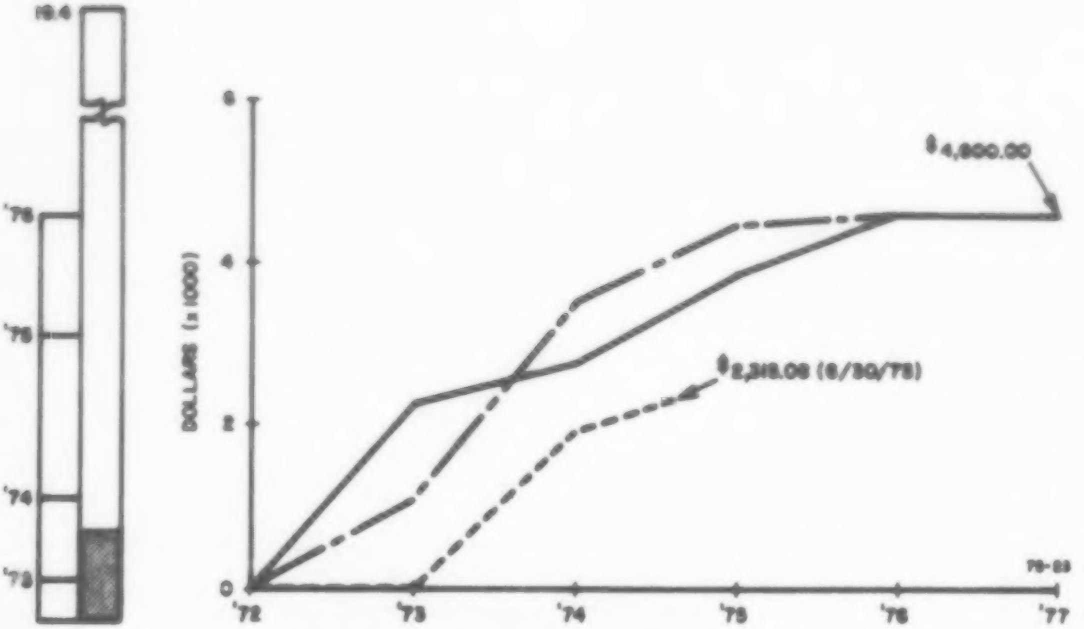


Figure 9.9 Critical Area Planting

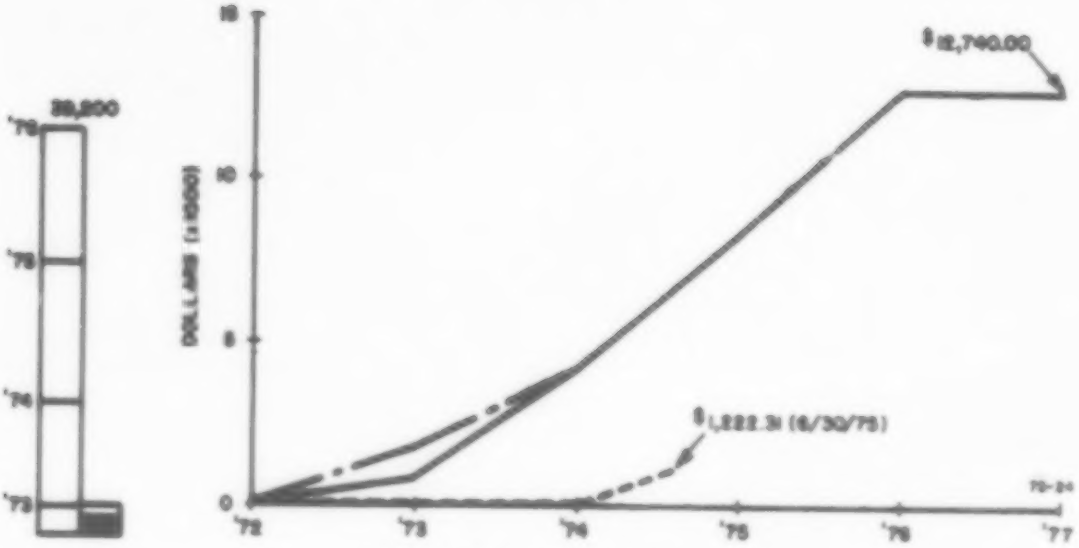


Figure 9.10 Diversion

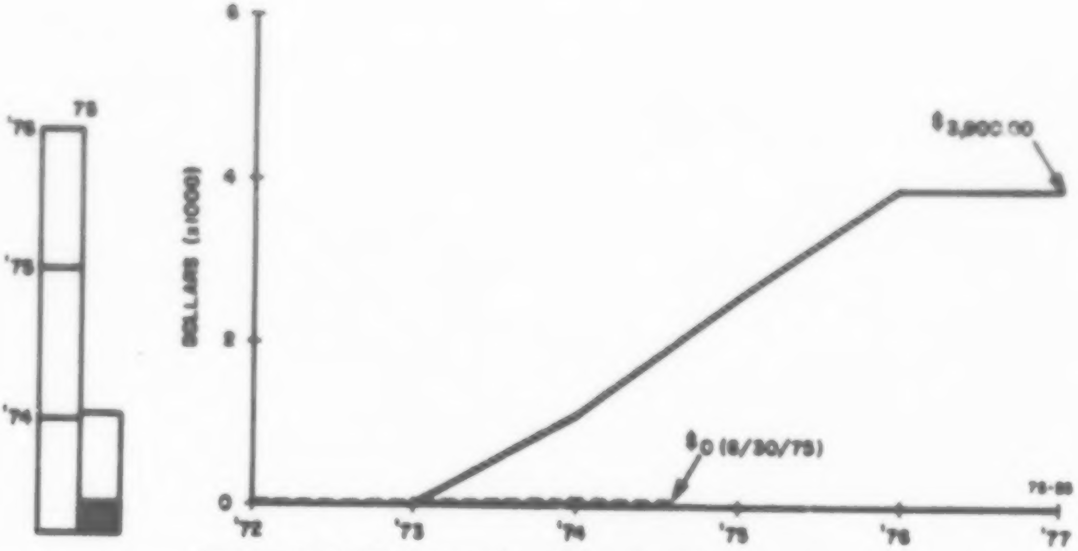


Figure 9.11 Farmstead and Feedlot Windbreaks

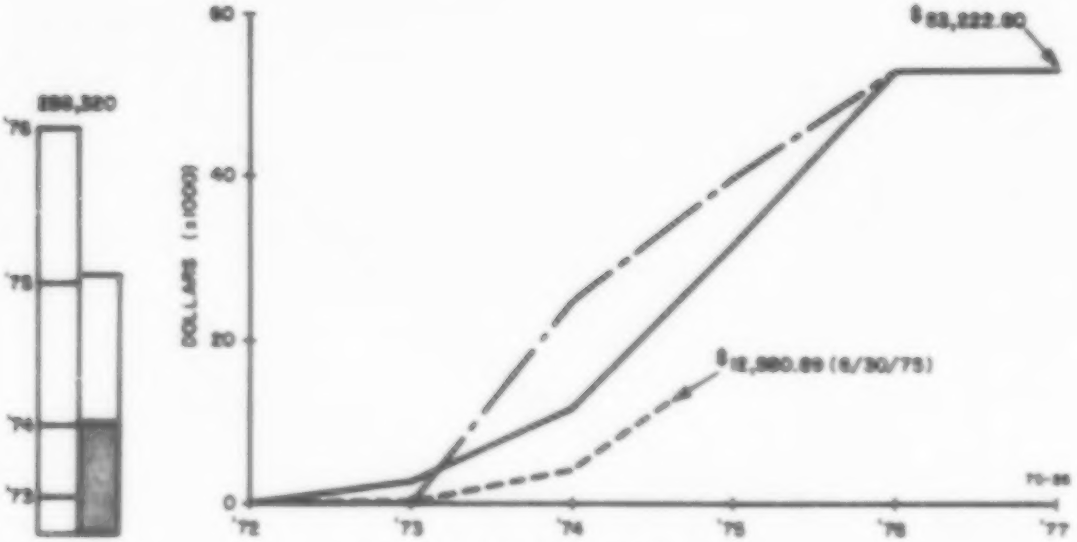


Figure 9.12 Field Border

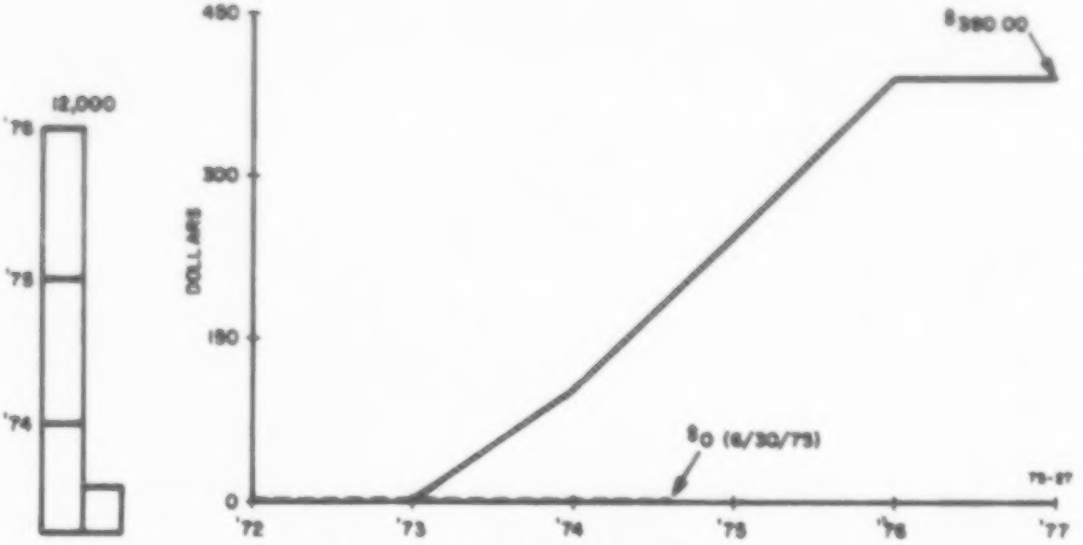


Figure 9.13 Field Windbreaks

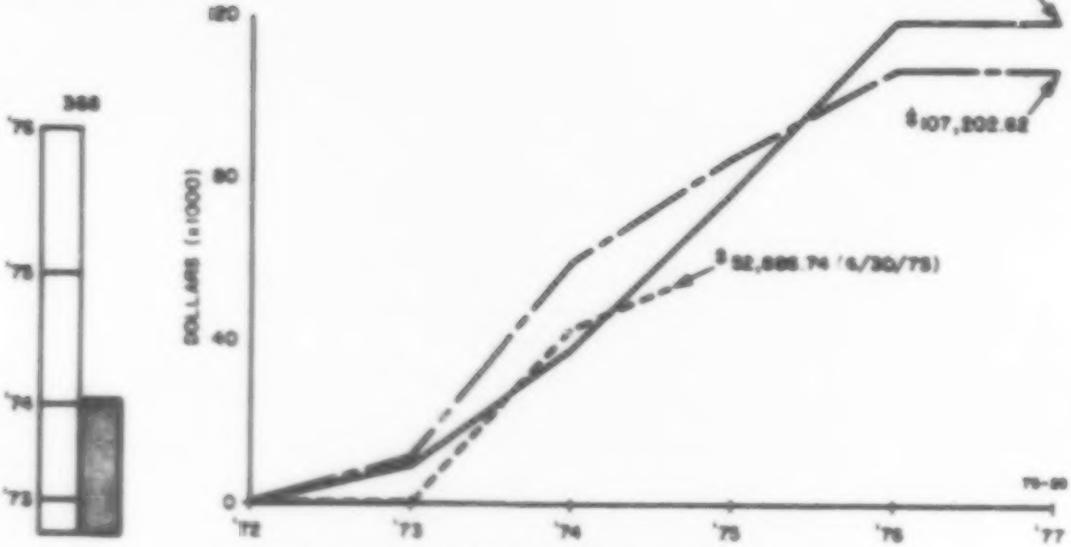


Figure 9.14 Grade Stabilization Structure

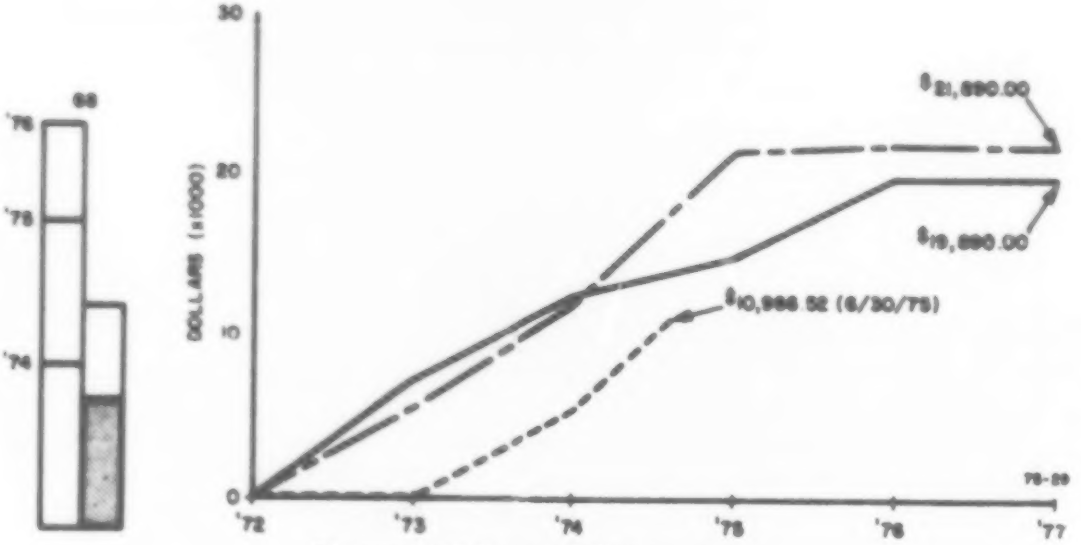


Figure 9.15 Grassed Waterways

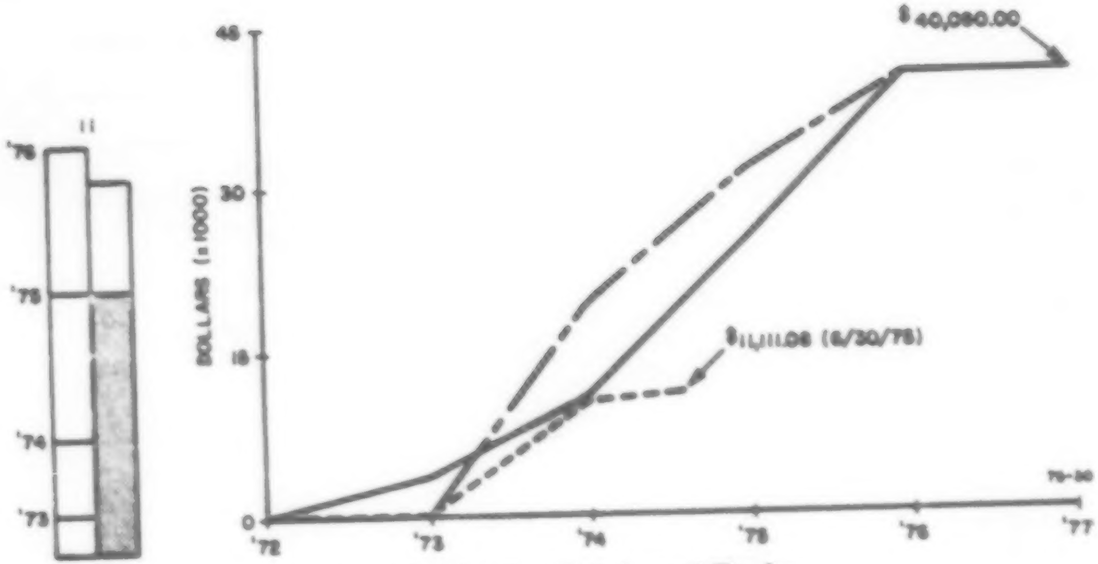


Figure 9.16 Holding Ponds and Tanks

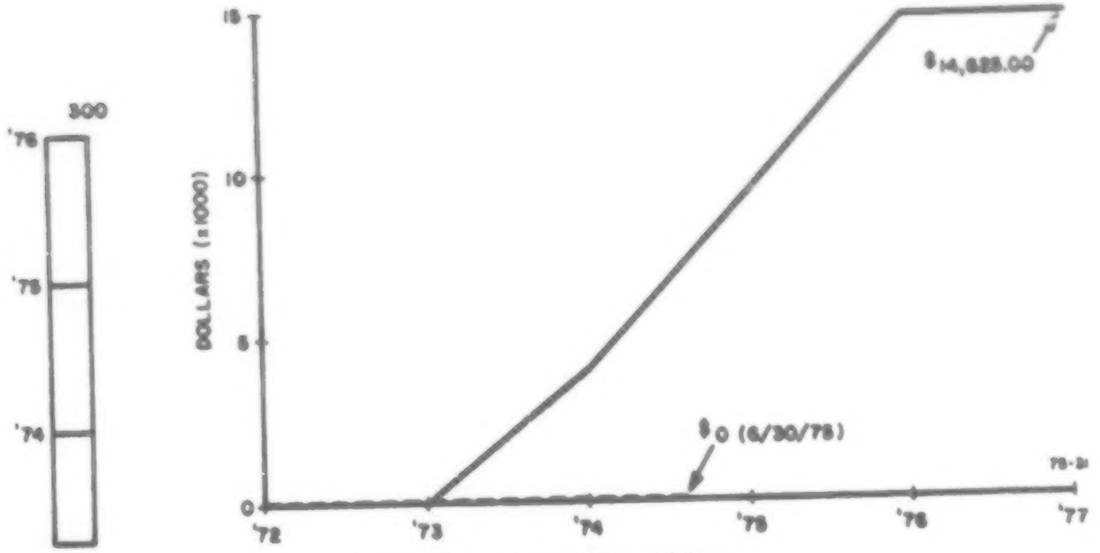


Figure 9.17 Land Smoothing

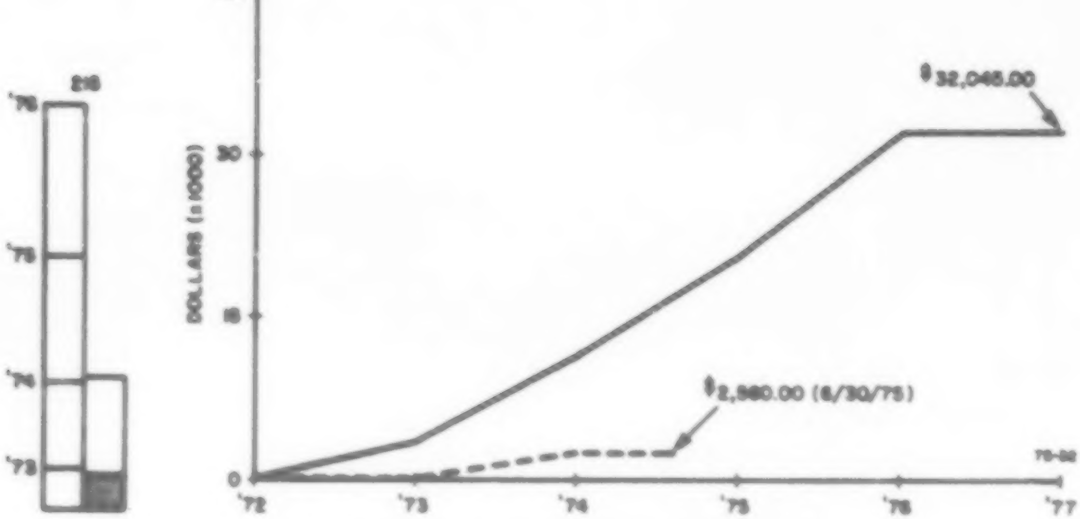


Figure 9.18 Livestock Exclusion (fencing)

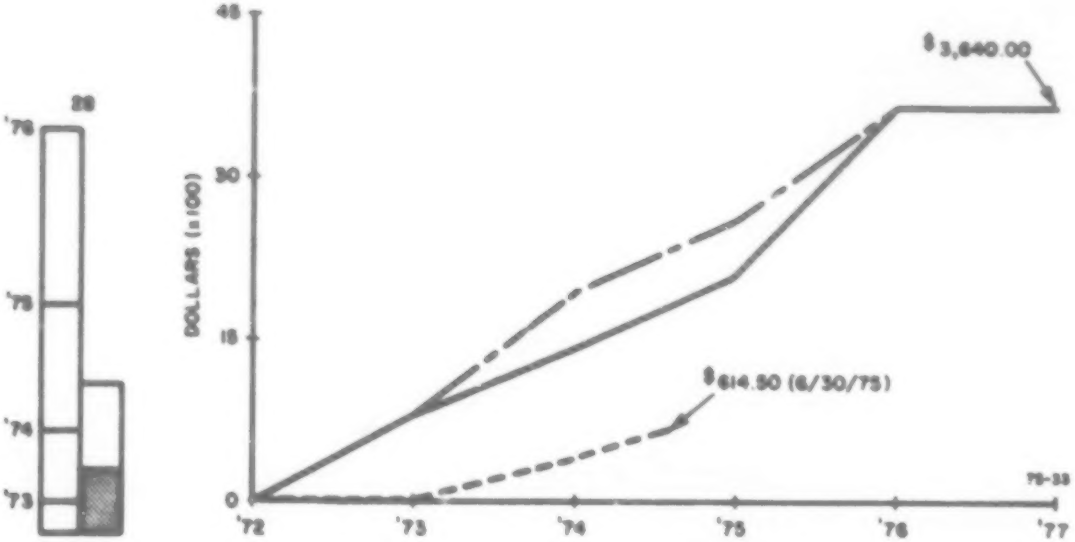


Figure 9.19 Livestock Watering Facility

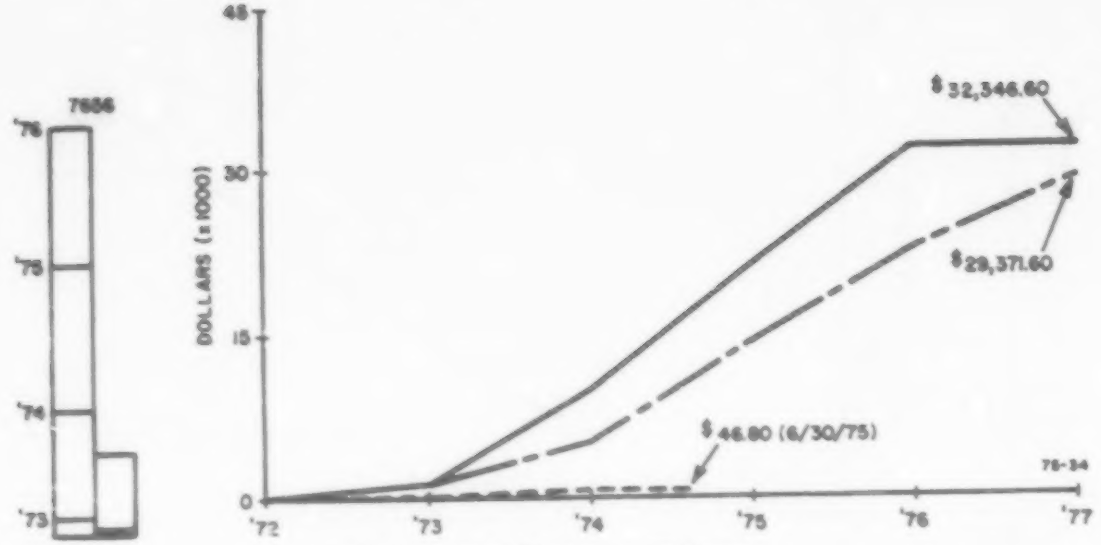


Figure 9.20 Minimum Tillage

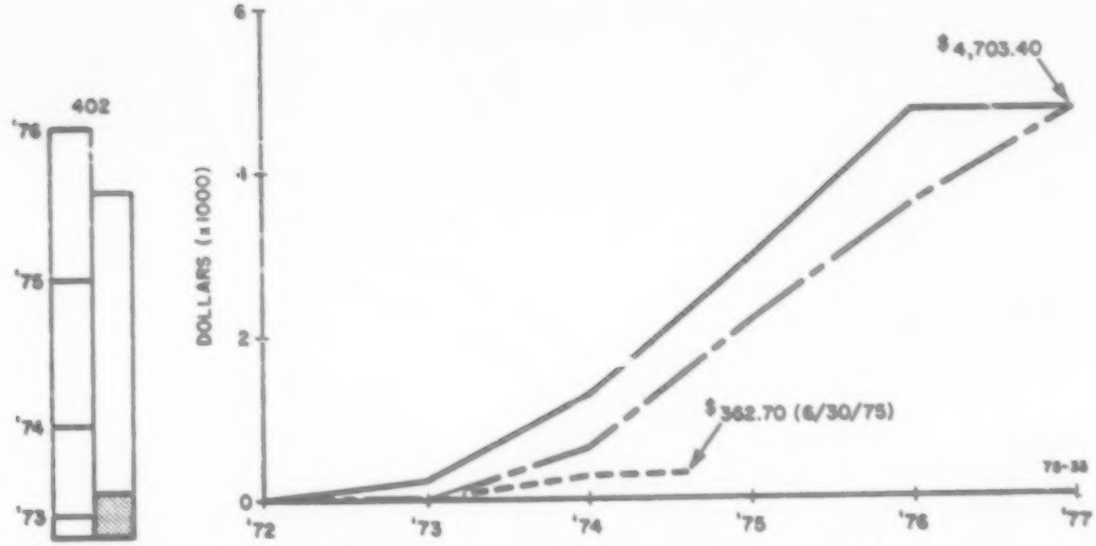


Figure 9.21 Pasture and Hayland Management

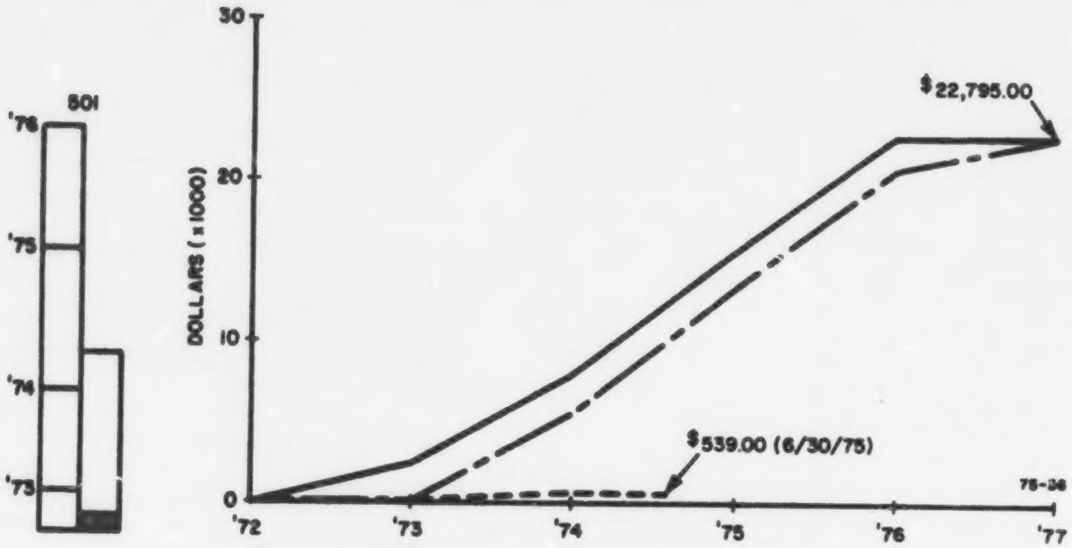


Figure 9.22 Pasture and Hayland Planting

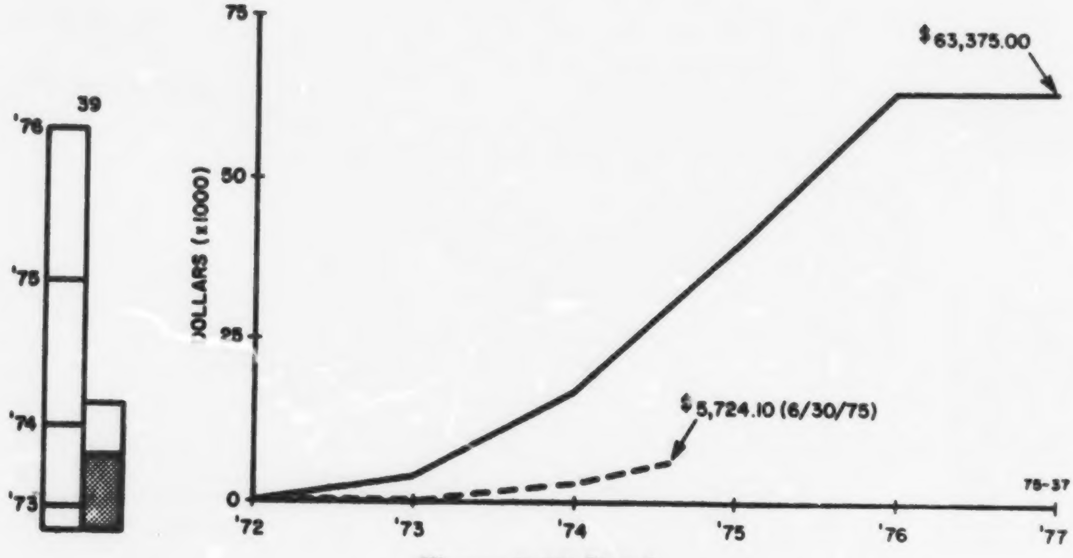


Figure 9.23 Pond

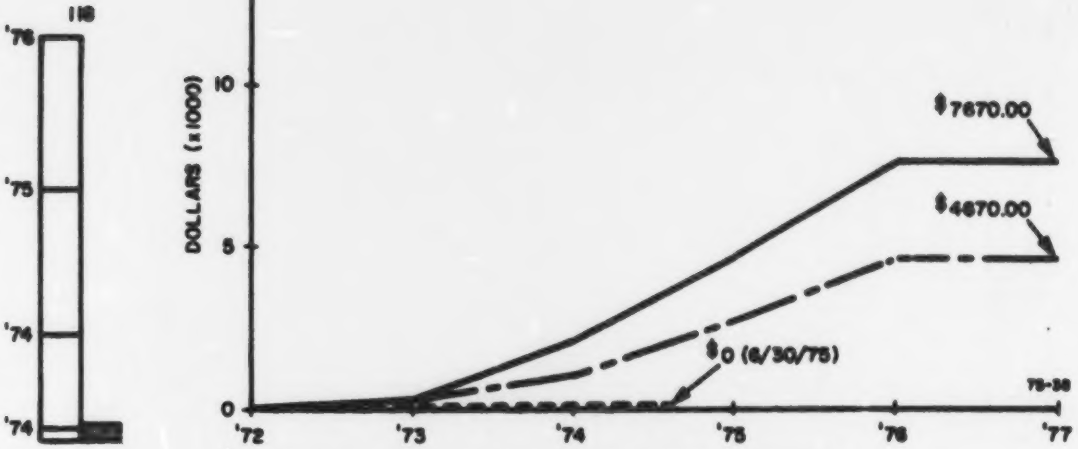


Figure 9.24 Protection During Development

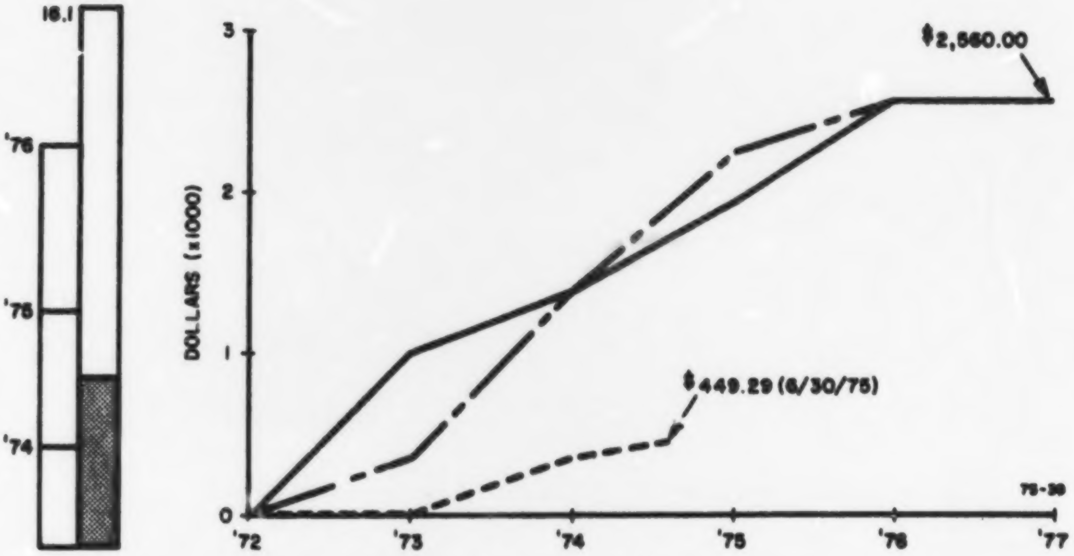


Figure 9.25 Recreation Area Improvement

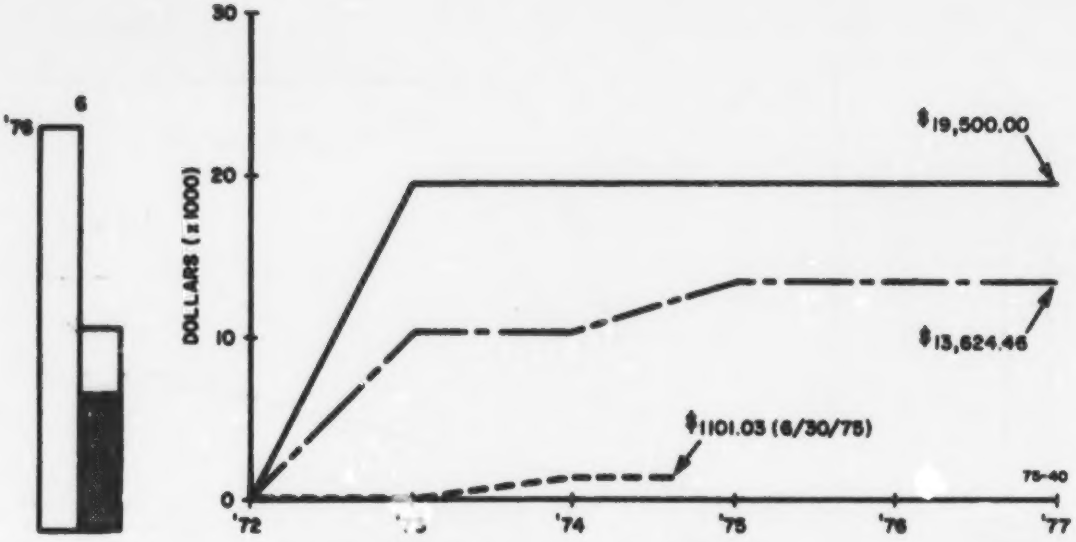


Figure 9.26 Sediment Control Basins

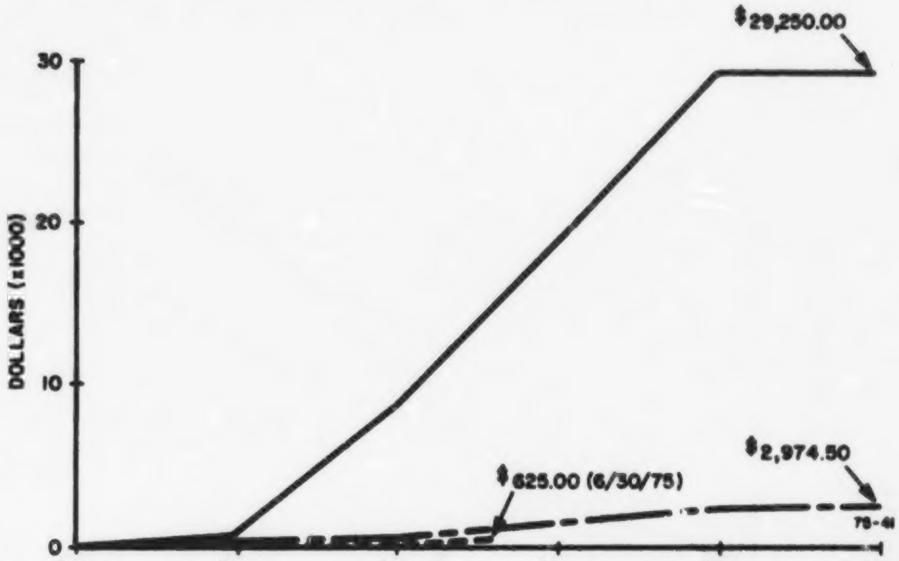


Figure 9.27 Conservation Field Trials

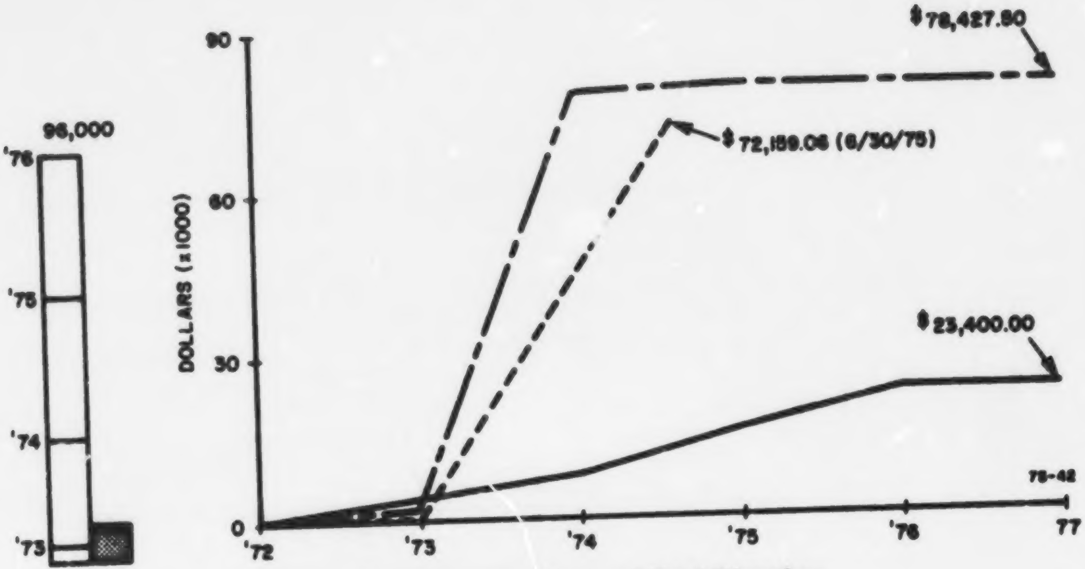


Figure 9.28 Stream Channel Stabilization

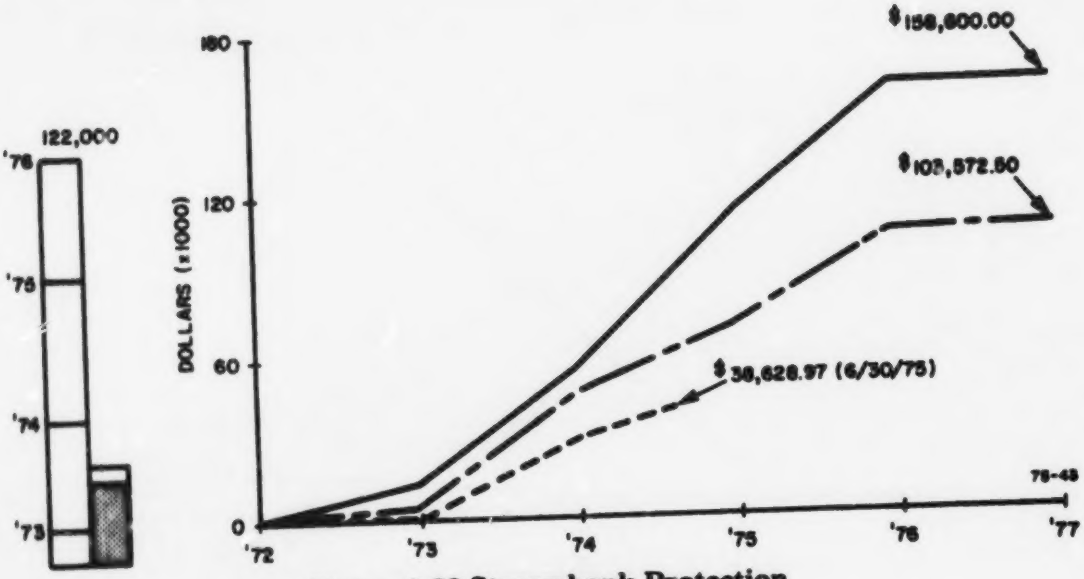


Figure 9.29 Streambank Protection

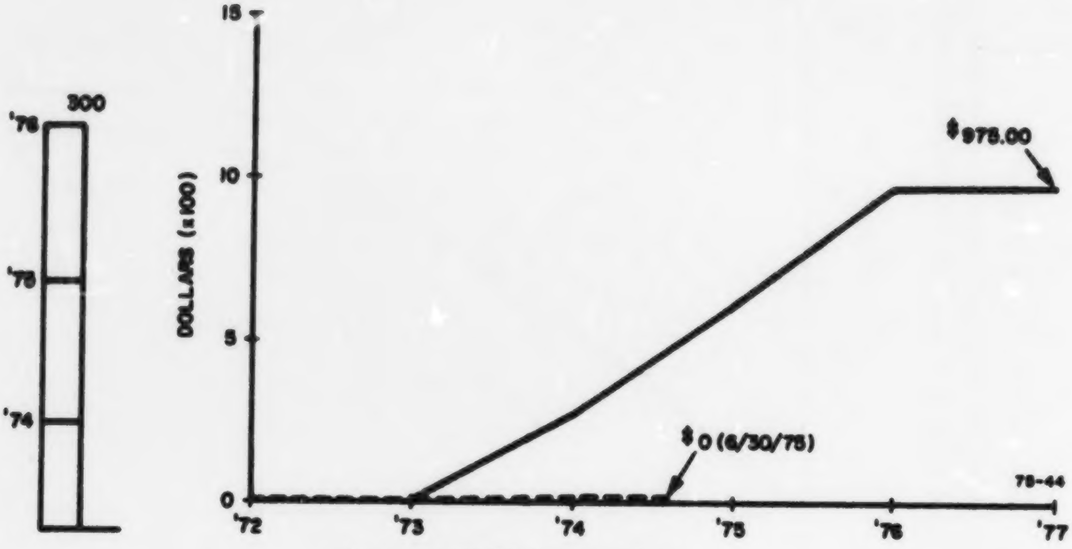


Figure 9.30 Stripcropping

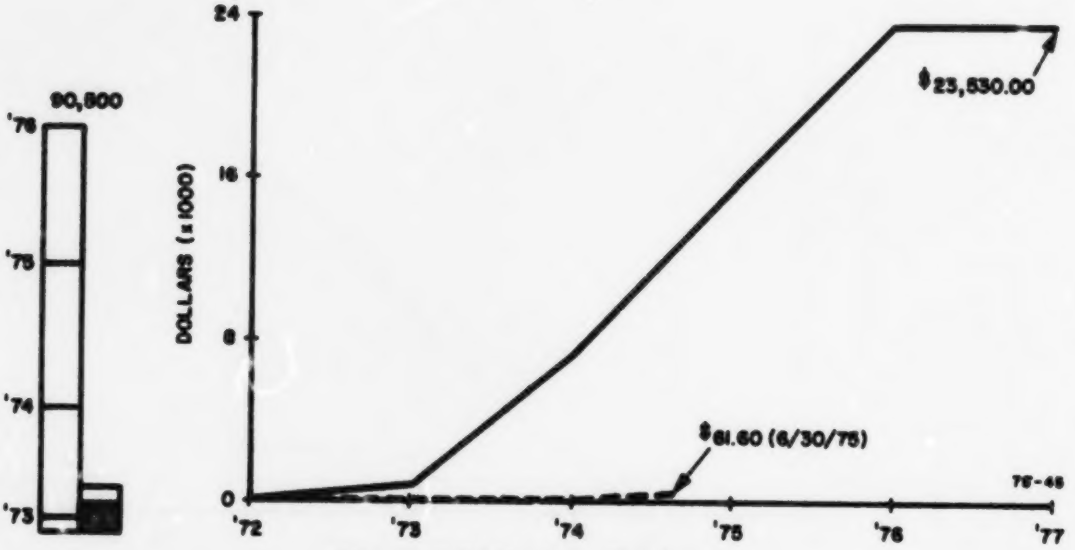


Figure 9.31 Surface Drains

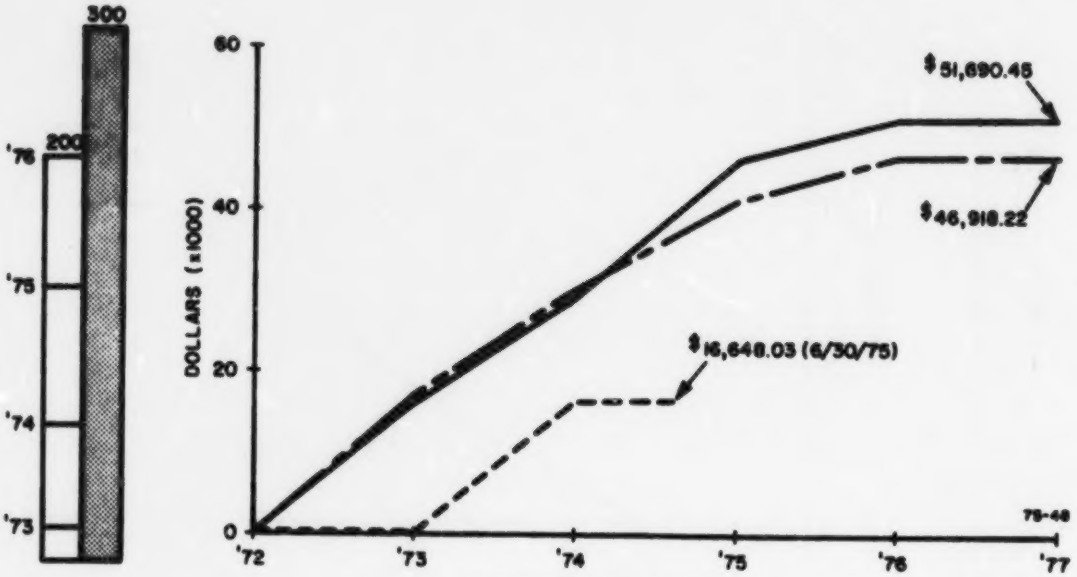


Figure 9.32 Tile Drains

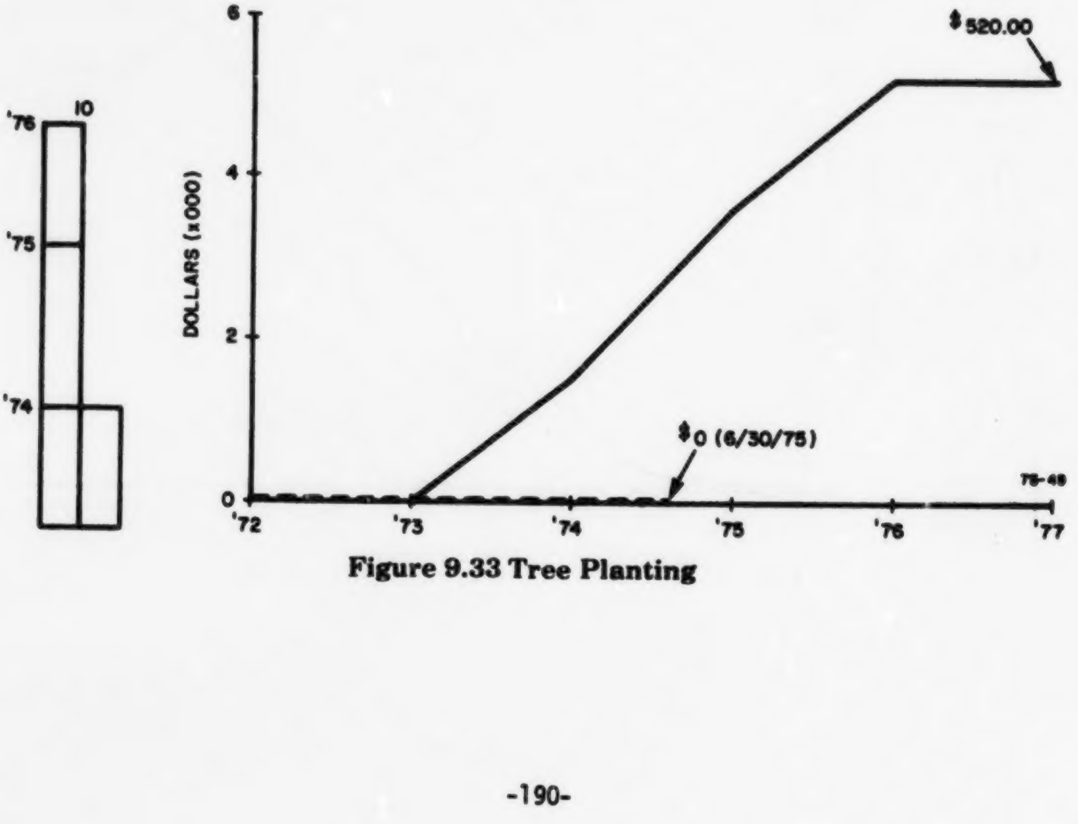


Figure 9.33 Tree Planting

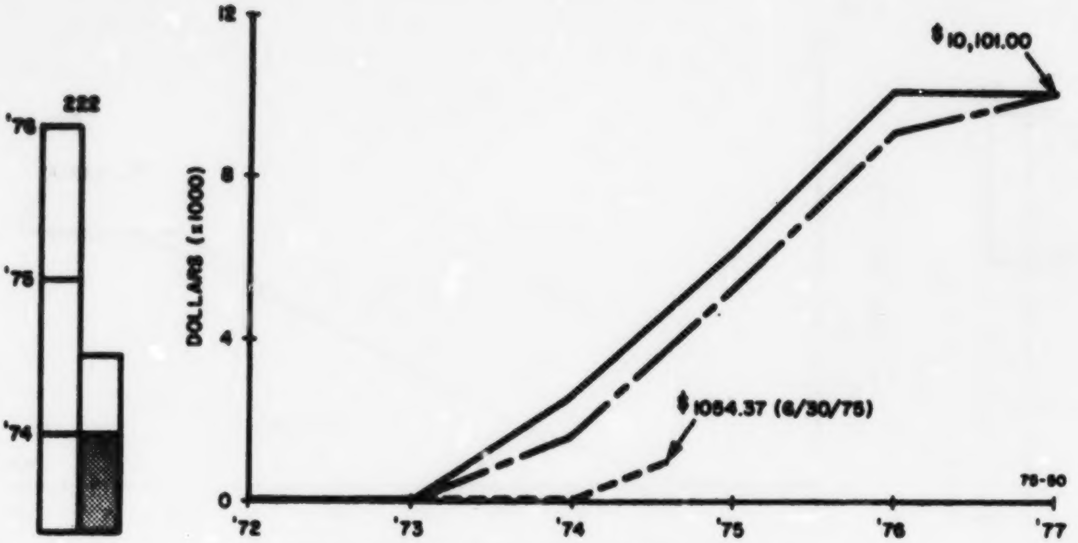


Figure 9.34 Wildlife Habitat Management

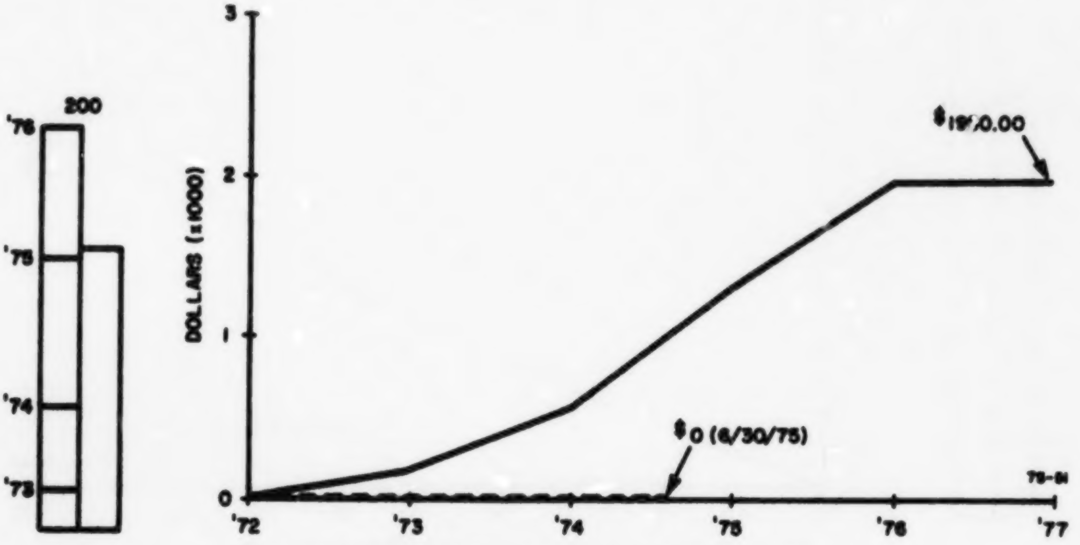


Figure 9.35 Woodland Improved Harvesting

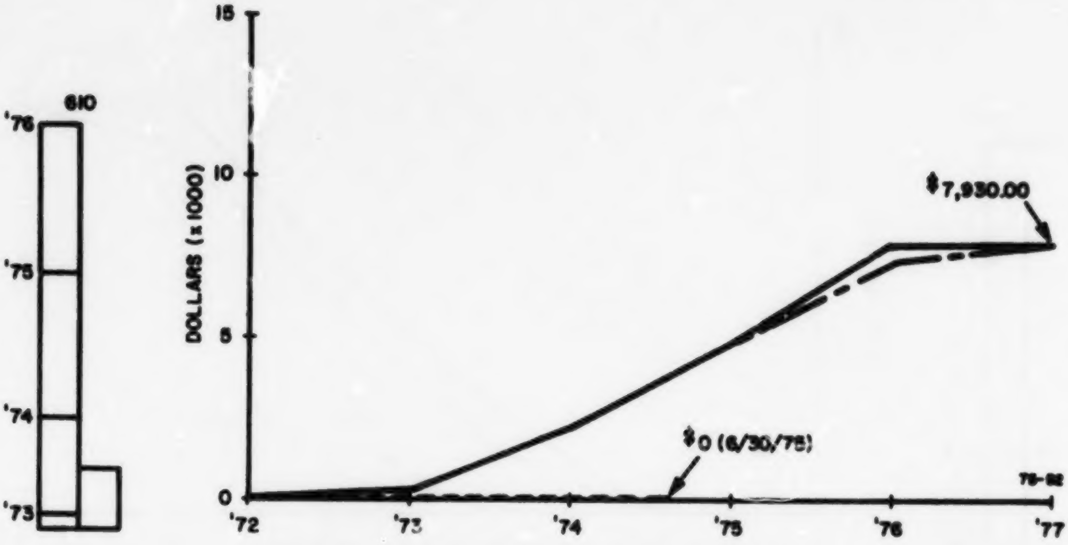


Figure 9.36 Woodland Improvement

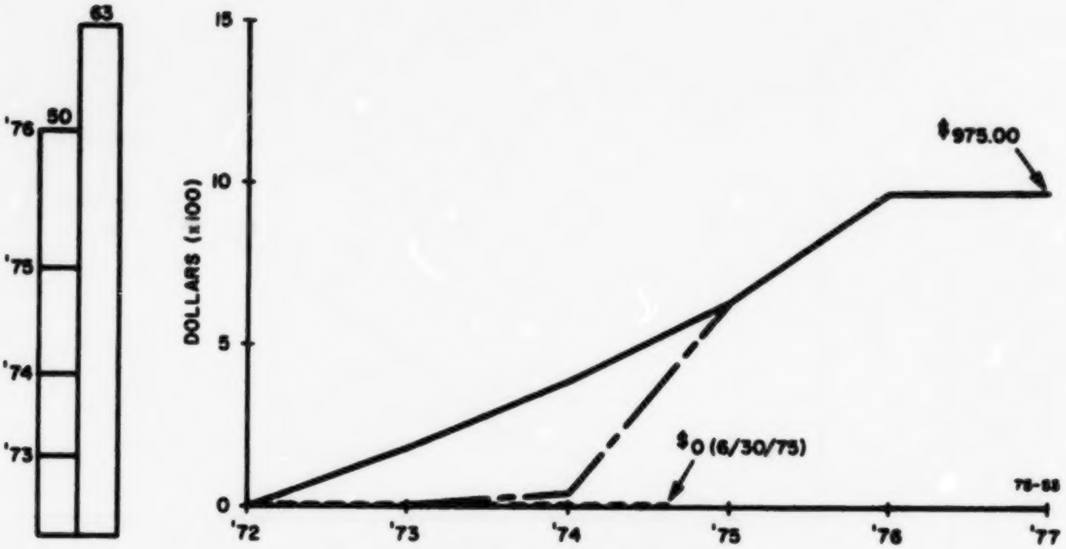


Figure 9.37 Woodland Pruning

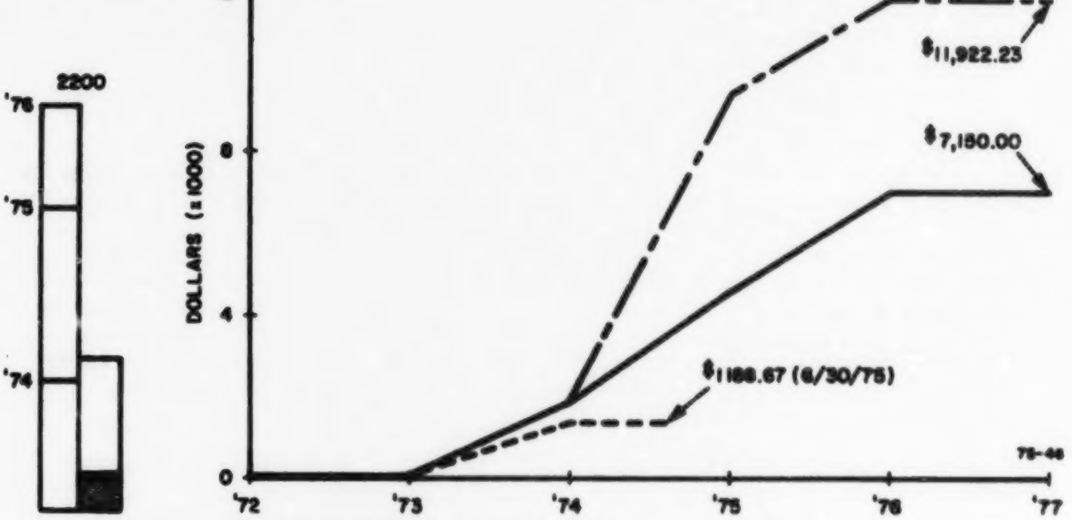


Figure 9.38 Terraces, Parallel and Gradient

MAINTENANCE

In developing the format and procedure for conducting the Black Creek Study, the cost of necessary maintenance on practice application throughout the duration of the project was not adequately considered. Any time that a large amount of land treatment is accomplished on a concentrated watershed area, a certain cost for maintenance is unavoidable. This became very evident in the spring of 1975 when on May 20, the watershed received a four and one-half inch rain over a period of two and one-half hours. This was equivalent to a one hundred year rain. Many of the practices that were installed were able to handle the severe stress, however there were areas where excessive damage did occur. Also, other practices have shown evidence of needing continual maintenance. One shortcoming of using federal funds for cost-sharing assistance is that the landowners are quite willing to accept funds for new practices and new construction on their land. However when the greater amount of the money spent for those practices comes out of the federal dollar rather than their own, it is quite difficult to encourage them to spend the necessary money to maintain these practices thereafter.

More than $200,000 has been spent in large construction in the watershed, along the main channel and its tributaries. Each year there is going to be a need for several thousand dollars worth of maintenance. Private individuals often feel that roads, ditches and many other services should be provided to them at no cost by the county, state or federal government. The question must be asked, "who is the government?". Of course, the answer is the tax payers themselves. Therefore, any costs incurred by the governmental agencies for roads, drainage, erosion control, etc., is going to be generated out of tax dollars.

The usual procedure in Allen County for drainage maintenance and erosion control work is through land assessments by the County Surveyor's office to cover the cost of maintenance on legal drains. People in the Black Creek area often feel that money that has already been spent by them, for the reconstruction of the Black Creek drain is all they should have to spend, and that the county should maintain the drain. This creates difficulty for the surveyor. Due to our experimental and sometimes elaborate project work, we have created higher costs for maintaining the drainage system in the Black Creek watershed. In looking back at the development of the Black Creek project one would probably insist that so many dollars be set aside for maintenance costs to cover the cost of necessary repair work that comes about during a project of this type. If a project like Black Creek is to be conducted again, maintenance should be considered as a very high priority in the program organization.

PLANS FOR COMING YEAR

Land Treatment

Several things are being considered to improve the land treatment accomplishments in the coming year, including employment of another district employee to contact landowners who have a plan for applying conservation practices sometime during the program period. The follow-up specialist being considered would spend his time seeing to it that scheduled land treatment practices are actually installed. Our experience in the past has been that unless the farmer is contacted during the critical times when installation of the practices must be accomplished, landowners may overlook the practice and delay installing it. The hiring of a follow-up specialist would probably increase the amount of actual practice installation significantly. Since there are only two construction seasons left in the project period, a strong follow-up program is essential.

The original scope of the project was to start planning on the west side of the watershed area progressing eastward until the entire watershed was canvassed. Data collected by Purdue have indicated that it is going to be difficult to recognise water quality changes as a result of land treatment activities. Therefore, the district has directed soil conservation personnel to concentrate planning activities on the Dreisbach Drain located on the west side of the watershed in order to maintain the highest concentration of land treatment possible. Hopefully this will give Purdue every chance possible to detect any results of concentrated land treatment in a subwatershed area. Further land treatment over broad areas of the watershed would not be significant to the monitoring program. In order to attempt to gain a high level of land treatment in the Dreisbach Drain subwatershed, the district has increased its cost-sharing rates on several critical erosion control practices.

As of next year, grass waterways, terraces, sediment control basins and several other erosion control practices most significant to the upland areas of the watershed will be cost-shared at 90 percent. This gives Soil Conservation Service planners a chance to recontact landowners who were not cooperative in the early stages of the program to see if they can encourage them to cooperate with the higher cost-share incentives. Purdue will attempt to detect through their data collection any water quality change that can be attributed to land treatment in the area of heavy application versus the areas in the eastern portion of the watershed where application of land treatment practices have been avoided. It is important to note, however, that the sub-watershed, Dreisbach in the western portion of Black Creek has a large concentration of rolling up land soils. The eastern portion of the Black Creek area has a large concentration of level lake bed soils. Therefore land treatment practices are needed much greater in the Dreisbach area. One thing that concerns both the district and the representatives doing the modeling and predictions for Purdue is that to date it has been very difficult to even relate land treatment activities to water quality results. Hopefully some correlation can be detected in the coming years.

RESEARCH

In order to improve and expand the research and monitoring activities being conducted by Purdue University, three new programs will be started in the coming year. The first is a real time, on-line monitoring network for the automatic sampler stations in the Black Creek watershed. Dr. Larry Huggins has been awarded a contract from the Environmental Protection Agency as a part of the Black Creek project to install a complete weather station in the watershed area as well as a dedicated telephone line system which will relate direct information from the monitoring sites in the Black Creek watershed area to the computer terminal at the Purdue Lafayette campus. This will enable Purdue to automatically record the weather events as well as to rely on the automatic sampling system around the clock. It will also allow Purdue to have better control over when samples are taken. For example, the automatic samplers are now triggered by the volume of flow coming over a weir, with the new real time monitoring system Dr. Larry Huggins will be able to increase the number of samples that can be taken on the upside of the hydrograph and reduce the number of unnecessary samples taken on the downward side of the hydrograph. This new project will have a significant influence on the quality of data being collected in Black Creek area.

Another aspect to be undertaken during the next year is that of automatically sampling the tile drainage flow. Del Bottcher, a graduate assistant under Dr. Edwin Monke, had developed a pumping sampler which will sample the flow from tile drainage systems. Initial studies of tile drainage flows have indicated that there are measurable amounts of soil being carried through the drainage tile systems. By installing the automatic tile sampler, the quality and quantity of the samples will improve significantly. This will enable Purdue to pinpoint the amount of sediment that can be attributed to tile drainage transport.

The third change in the research and demonstration effort by Purdue University which will be seen next year relates to conservation tillage research. Our efforts in the last two years have been through small demonstration plots on several sites in the Black Creek area. This approach has proven to be rather unsuccessful because of the lack of controlled research with the small demonstration plots. The farmers who have cooperated with these small plot trial have not been interested to the point of maintaining a quality control. Without having replicated plots, the information being obtained from the small single plot trials has been almost useless in terms of research data. In order to improve this program, Dr. Don Griffith, a Purdue minimum tillage specialist, has requested the district to rent several large plots of approximately 20 acres each. This will allow Purdue to place a main in the watershed area to supervise and actually install the minimum tillage trial. This effort will involve the purchase of a tractor and planter and other equipment necessary to farm and maintain these research plots. The large plots will allow replicated trials sufficient to provide research data. If these plots are successful, they should serve as excellent educational tools which will help to encourage minimum tillage in the future. This more expanded approach to conservation field trials could hold many answers to the future successes or failures pertaining to minimum tillage in the Maumee Basin area.

SUMMARY

In summarizing the activities of the Black Creek Project to date, one can be quite satisfied and pleased with the accomplishments that have been recorded. Many needed answers will be obtained from the work being conducted on this project. This project should provide the type of information that is needed for future decisions relating to land use and water quality. As director of the Black Creek Project I am looking forward with great anticipation to the activities of the coming year, and I am appreciative of the great effort and cooperation that has been received from all participating agencies and private landowners. May this project be one for which we can all be proud of for many years to come.

APPENDIX #1

Computer Print-Out
Allen County Data Processing

SOIL & WATER CONSERVATION

DATE 10/17/75

PROJECT OVERVIEW

PAGE 1

ACCOUNT NO.	TITLE		FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
	*** DISTRICT ***						
100-101	SALARY AND WAGES						
		APPROPRIATED	2,150.00	7,912.50	12,200.00	2,300.00	2,400.00
		PAYMENTS	516.50	6,225.00	10,285.00		
		COMMITMENTS					
		UNENCUMBERED	1,633.50	1,687.50	1,915.00	2,300.00	2,400.00
100-102	FRINGE BENEFITS						
		APPROPRIATED	180.00	63.04	397.38		
		PAYMENTS		63.04	397.38		
		COMMITMENTS					
		UNENCUMBERED	180.00				
100-103	CONSULTANT SERVICES						
		APPROPRIATED					
		PAYMENTS					
		COMMITMENTS					
		UNENCUMBERED					
100-104	EQUIPMENT						
		APPROPRIATED	910.73	899.08	900.00	500.00	356.19
		PAYMENTS	910.73	899.08	784.87		
		COMMITMENTS					
		UNENCUMBERED			115.13	500.00	356.19
100-105	SUPPLIES						
		APPROPRIATED	175.00	200.00	200.00	200.00	200.00
		PAYMENTS	101.10	90.78	130.28		
		COMMITMENTS					
		UNENCUMBERED	73.90	109.22	69.72	200.00	200.00

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SOIL & WATER CONSERVATION

PROJECT OVERVIEW

DATE 10/17/75

ACCOUNT NO.	TITLE		FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
100-106	TRAVEL						
		APPROPRIATED	410.00	545.00	800.00	100.00	
		PAYMENTS	410.00	539.32	770.32		
		COMMITMENTS					
		UNENCUMBERED		5.68	29.68	100.00	
100-107	PUBLICATION COSTS						
		APPROPRIATED	197.08	877.92	50.00	50.00	100.00
		PAYMENTS	197.08	838.26	15.96		
		COMMITMENTS					
		UNENCUMBERED		39.66	34.04	50.00	100.00
100-108	OTHER - GOV. UNITS						
		APPROPRIATED		500.00	1,000.00	900.00	1,000.00
		PAYMENTS			185.82		
		COMMITMENTS					
		UNENCUMBERED		500.00	814.18	900.00	1,000.00
100-109	SAVINGS ACCOUNT						
		APPROPRIATED					
		PAYMENTS					
		COMMITMENTS					
		UNENCUMBERED					
	DISTRICT TOTALS						
		APPROPRIATED	4,072.81	10,997.54	15,547.38	4,050.00	4,056.19
		PAYMENTS	2,135.41	8,655.48	12,569.63		
		COMMITMENTS					
		UNENCUMBERED	1,887.40	2,342.06	2,977.75	4,050.00	4,056.19

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SOIL & WATER CONSERVATION

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PROJECT OVERVIEW

ACCOUNT NO.	TITLE		FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
	*** PURDUE ***						
200-201	SALARIES						
		APPROPRIATED	4,485.81	91,926.21	114,466.98	87,145.00	87,177.00
		PAYMENTS	4,485.81	91,926.21	94,217.25		
		COMMITMENTS					
		UNENCUMBERED			20,249.73	87,145.00	87,177.00
200-202	FRINGE BENEFITS						
		APPROPRIATED	462.39	3,461.57	3,292.04	2,132.00	2,725.00
		PAYMENTS	462.39	3,461.57	3,037.58		
		COMMITMENTS					
		UNENCUMBERED			254.46	2,132.00	2,725.00
200-203	EQUIPMENT						
		APPROPRIATED		24,548.62	14,876.38	4,000.00	4,000.00
		PAYMENTS		24,548.62	8,977.99		
		COMMITMENTS					
		UNENCUMBERED			5,898.39	4,000.00	4,000.00
200-204	SUPPLIES AND EXPENSES						
		APPROPRIATED	128.43	23,256.52	23,685.05	15,500.00	10,700.00
		PAYMENTS	128.43	21,882.37	19,064.65		
		COMMITMENTS					
		UNENCUMBERED		1,374.15	4,620.40	15,500.00	10,700.00
200-205	TRAVEL AND PER DIEM						
		APPROPRIATED	7,000.00	19,700.00	14,700.00	15,000.00	12,100.00
		PAYMENTS	1,400.36	16,394.23	13,755.92		
		COMMITMENTS			364.00		
		UNENCUMBERED	5,599.64	3,305.77	580.08	15,000.00	12,100.00

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S O I L & W A T E R C O N S E R V A T I O N

DATE 10/17/75

P R O J E C T O V E R V I E W

ACCOUNT NO.	TITLE		FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
200-206	CONSTRUCTION						
		APPROPRIATED		19,904.54	10,295.46		
		PAYMENTS		19,904.54	10,293.30		
		COMMITMENTS					
		UNENCUMBERED			2.16		
200-208	OTHER RESEARCH EXPENSES						
		APPROPRIATED	1,275.00	3,850.00	7,500.00	7,500.00	8,000.00
		PAYMENTS		1,222.70	2,743.78		
		COMMITMENTS					
		UNENCUMBERED	1,275.00	2,627.30	4,756.22	7,500.00	8,000.00
200-209	INDIRECT COST						
		APPROPRIATED	2,884.38	55,888.21	68,658.41	52,354.00	52,145.00
		PAYMENTS	2,884.38	55,888.21	60,584.85		
		COMMITMENTS					
		UNENCUMBERED			8,073.56	52,354.00	52,145.00
	PURDUE TOTALS						
		APPROPRIATED	16,236.01	242,735.67	257,474.32	183,631.00	176,847.00
		PAYMENTS	9,361.37	235,428.45	212,675.32		
		COMMITMENTS			364.00		
		UNENCUMBERED	6,874.64	7,307.22	44,435.00	183,631.00	176,847.00

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SOIL & WATER CONSERVATION

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PROJECT OVERVIEW

ACCOUNT NO.	TITLE		FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
	*** SOIL CONSERVATION SERVICE						
300-301	PROFESSIONAL SALARY & BENIFITS						
		APPROPRIATED	21,514.02	40,760.98	36,650.00	16,500.00	13,025.00
		PAYMENTS	21,514.02	36,034.17	18,863.11		
		COMMITMENTS					
		UNENCUMBERED		4,726.81	17,786.89	16,500.00	13,025.00
300-302	SUB-PROFESSIONAL SALARY & BEN						
		APPROPRIATED	5,852.45	22,183.55	18,641.00	18,437.00	
		PAYMENTS	5,852.45	21,863.56	7,748.48		
		COMMITMENTS					
		UNENCUMBERED		319.99	10,892.52	18,437.00	
300-305	CARTOGRAPHIC COST						
		APPROPRIATED	1,500.00				
		PAYMENTS	914.53				
		COMMITMENTS					
		UNENCUMBERED	585.47				
300-306	SOIL MECHANICS TESTING COST						
		APPROPRIATED		2,300.00			
		PAYMENTS		1,761.75			
		COMMITMENTS					
		UNENCUMBERED		538.25			
300-307	OTHERS						
		APPROPRIATED					
		PAYMENTS					
		COMMITMENTS					
		UNENCUMBERED					

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SOIL & WATER CONSERVATION

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PROJECT OVERVIEW

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ACCOUNT NO.	TITLE	FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
	SOIL CONSERVATION SRVC TOTALS					
	APPROPRIATED	28,866.47	65,244.53	55,291.00	34,937.00	13,025.00
	PAYMENTS	28,281.00	59,659.48	26,611,59		
	COMMITMENTS					
	UNENCUMBERED	585.47	5,585.05	28,679.41	34,937.00	13,025.00

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SOIL & WATER CONSERVATION
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200-205		TRAVEL AND PER DIEM		7,000.00	19,700.00	14,700.00	15,000.00	12,100.00
200	2060000286	PURDUE RESEARCH FOUNDATION	01/07/75			364.00		
		TOTAL PAID		1,400.36	16,394.23	13,755.92		
		TOTAL COMMITTED				364.00		
		TOTAL UNENCUMBERED BALANCE		5,599.64*	3,305.77*	580.00*	15,000.00*	12,100.00*
400-401		CONSERVATION CROPPING SYSTEM		85.00	2,928.55	2,570.75	1,148.25	500.00
000	2700160012	LAVERN STEURY	06/03/75				15.60	
000	2700160012	LAVERN STEURY	06/03/75				15.60	
000	2700160010	PERRY E POISEL	07/14/75				21.00	
000	2700160014	EMANUEL BRANDENBERGER	07/14/75				15.60	
000	2200010004	MAX ARCHIBOLD	08/28/74			7.20		
000	2700220006	KENNETH JAMES	08/26/75				46.80	
000	2700200008	BEN EICHER	09/10/74			124.80		
000	2700330009	ALFRED E APPLEGATE	09/25/74			98.40		
000	2700330024	NOAH LENGACHER	11/26/74			104.40		
		TOTAL PAID			2,203.20	1,627.20		
		TOTAL COMMITTED				334.80	114.60	
		TOTAL UNENCUMBERED BALANCE		85.00*	725.35*	608.75*	1,033.65*	500.00*
400-402		CONTOUR FARMING			266.50	354.90	278.30	100.00
000	2700200008	BEN EICHER	09/10/74			16.00		
000	2700200008	BEN EICHER	09/10/74				24.00	
000	2100060007	VIRGIL HIRSCH	10/02/73			16.00		
000	2100060007	VIRGIL HIRSCH	10/02/73				*	16.00
000	2700190001	JACOB J GRABER	10/18/74				12.80	
		TOTAL PAID						
		TOTAL COMMITTED				32.00	36.80	16.00
		TOTAL UNENCUMBERED BALANCE		*	266.50*	322.90*	241.50*	84.00*
400-403		CRITICAL AREA PLANTING		1,090.00	2,125.00	1,384.92		
000	2100080005	HERBERT WOEBBEKING	01/02/74		640.00			
000	M1	JOSEPH R GRABER	06/28/74		260.00			
000	2700160009	VICTOR SCHMUCKER	07/14/75			260.00		
000	2100050007	HELEN WEIKER	08/15/75			260.00		
000	2100050006	KENNETH HIRSCH	09/03/74			520.00		
000	2100050016	MAX WOEBBEKING	10/01/74			320.00		
		TOTAL PAID		1,090.00	1,225.00			
		TOTAL COMMITTED			900.00	1,360.00		
		TOTAL UNENCUMBERED BALANCE		*	*	24.92*	*	*
400-404		CROP RESIDUE MANAGEMENT			498.75	2,096.75	4,132.90	3,575.00
000	2100080003	CHRIS ROEHKE	01/02/74				27.30	
000	2100080003	CHRIS ROEHKE	01/02/74					27.30
000	2100080005	HERBERT WOEBBEKING	01/02/74				40.95	
000	2100080005	HERBERT WOEBBEKING	01/02/74					31.50
001	2200020014	JUANITA E LAKE	01/02/74			14.70		
002	2200020014	JUANITA E LAKE	01/02/74				30.43	
003	2200020014	JUANITA E LAKE	01/02/74					45.15
001	2700160019	DENNIS A BENNETT	01/02/74			9.45		

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P.O	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
001	2700160019	DENNIS A BENNETT	01/02/74				9.45	
002	2700160019	DENNIS A BENNETT	01/02/74					4.20
000	2700290013	FOGLE BROTHERS	01/03/74				149.10	
000	2700290013	FOGLE BROTHERS	01/03/74					149.10
000	2700350005	MARVIN STIEGLITZ	01/04/74			191.10		
000	2700350005	MARVIN STIEGLITZ	01/04/74				191.10	
000	2700350005	MARVIN STIEGLITZ	01/04/74					191.10
000	2700210001	VICTOR SCHMUCKER	01/14/75				336.00	
000	2700210001	VICTOR SCHMUCKER	01/14/75					152.00
000	2700260012	ALFRED ROEMKE	01/24/75				91.20	
000	2700260012	ALFRED ROEMKE	01/24/75					91.20
000	2700280010	ALVIN LENGACHER	02/03/75				320.00	
000	2700280010	ALVIN LENGACHER	02/03/75					384.00
000	2700330019	VIVIAN LOUDEN	02/27/75				75.60	
000	2700330019	VIVIAN LOUDEN	02/27/75					75.60
000	2200010006	KENNETH SCHLATTER	03/05/74				210.00	
000	2200010006	KENNETH SCHLATTER	03/05/74					210.00
000	2700210003	DON A WOLF	04/01/75				384.00	
000	2700210003	DON A WOLF	04/01/75					384.00
000	2700260005	RALPH THIMLAR	04/20/75				12.00	
000	2200020003	MARGUERITA YODER	05/07/74			56.70		
000	2200020003	MARGUERITA YODER	05/07/74				56.70	
000	2200020003	MARGUERITA YODER	05/07/74					56.70
000	2200020005	DELBERT DELAGRANGE	05/07/74				31.50	
000	2200020005	DELBERT DELAGRANGE	05/07/74					31.50
000	2200020015	FRANKLYN WADE	05/07/74			4.20		
000	2200020015	FRANKLYN WADE	05/07/74				* 4.20	
000	2200020015	FRANKLYN WADE	05/07/74					4.20
000	2200020018	HARRIETT DANIELS	05/07/74				30.45	
000	2200020018	HARRIETT DANIELS	05/07/74					30.45
000	0221001117	GENE FUELLING	05/08/74				115.50	
000	0221001117	GENE FUELLING	05/08/74					115.50
000	2700280008	JOHN LENGACHER	05/28/74				38.85	
000	2700280008	JOHN LENGACHER	05/28/74					31.50
000	2200010018	RAY GERIG	06/03/74			35.70		
000	2200010018	RAY GERIG	06/03/74				35.70	
000	2200010018	RAY GERIG	06/03/74					35.70
000	2700320001	KENNETH AMSTUTZ	06/03/74				26.25	
000	2700320001	KENNETH AMSTUTZ	06/03/74					26.25
000	2700270002	ROGER EHLE	06/04/74			29.40		
000	2100060003	RICHARD YERKS	06/14/74				127.05	
000	2100060003	RICHARD YERKS	06/14/74					127.05
000	2100060005	BRUCE YERKS	06/14/74				24.15	
000	2100060005	BRUCE YERKS	06/14/74					24.15
000	2700290009	MENNO LENGACHER	06/17/74				74.55	
000	2700290009	MENNO LENGACHER	06/17/74					74.55
000	2700350004	OLIVER STIEGLITZ	06/18/74				39.90	
000	2700350004	OLIVER STIEGLITZ	06/18/74					39.90
000	2200010003	J GLADWYN KLOPFENSTEIN	07/29/74				29.40	
000	2200010003	J GLADWYN KLOPFENSTEIN	07/29/74					29.40
000	2200010005	HERBERT GERIG	07/29/74				42.00	
000	2200010005	HERBERT GERIG	07/29/74					42.00
000	2100050007	HELEN WEIKER	08/15/75				51.60	
000	2100050007	HELEN WEIKER	08/15/75					51.60

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000	2200010004	MAX ARCHIBOLD	08/26/74				6.30	
000	2200010004	MAX ARCHIBOLD	08/26/74					6.30
000	2200010004	MAX ARCHIBOLD	08/26/74					6.30
000	2700220006	KENNETH JAMES	08/26/75				46.80	
000	2200010014	PAUL KORTE	08/27/74			115.50		
000	2200010014	PAUL KORTE	08/27/74				115.50	
000	2200010014	PAUL KORTE	08/27/74					115.50
000	2100050006	KENNETH HIRSCH	09/03/74				54.60	
000	2100050006	KENNETH HIRSCH	09/03/74					54.60
000	2700340011	GUY BEERBOWER	09/03/74				312.90	
000	2700340011	GUY BEERBOWER	09/03/74					312.90
000	2700330009	ALFRED E APPLEGATE	09/25/74			21.00		
000	2700340008	WILLIAM YERKS	10/24/74				60.90	
000	2700340008	WILLIAM YERKS	10/24/74					60.90
000	2700350008	LOIS DEAN	10/24/74				69.30	
000	2700350008	LOIS DEAN	10/24/74					69.30
000	2200020019	PAUL ANSTUTZ	10/31/74				52.90	
000	2200020019	PAUL ANSTUTZ	10/31/74					52.90
000	2200110001	WAYNE GERIG	11/04/74				36.75	
000	2200110001	WAYNE GERIG	11/04/74					36.75
000	2200120006	DALE GERIG	11/04/74				106.05	
000	2200120006	DALE GERIG	11/04/74					106.05
TOTAL PAID					309.75	1,118.00		
TOTAL COMMITTED					189.00	666.75	3,663.55	3,475.70
TOTAL UNENCUMBERED BALANCE				*	*	312.00*	869.35*	99.30*
400-405 DIVERSIONS				1,845.00	2,250.00	4,387.50	4,257.50	
002	2700260005	RALPH THIMLAR	04/20/75				45.00	
001	2700260005	RALPH THIMLAR	04/20/75				135.00	
000	2700210002	AMOS LENGACHER	07/14/75			90.00		
001	2700300001	DAVID LENGACHER	08/18/75			207.36		
002	2700300001	DAVID LENGACHER	08/18/75			45.00		
004	2700300001	DAVID LENGACHER	08/18/75			63.00		
003	2700300001	DAVID LENGACHER	08/18/75			67.50		
000	2700200008	BEN EICHER	11/22/74			483.94		
TOTAL PAID				1,031.25	191.06			
TOTAL COMMITTED						956.80	180.00	
TOTAL UNENCUMBERED BALANCE				813.75*	2,058.94*	3,430.70*	4,077.50*	*
400-406 FARMSTEAD & FEEDLOT WINDBREAKS					1,092.00	1,456.00	1,352.00	
000	2100050010	ELMER C BOHREN	12/10/74			32.00		
TOTAL PAID						169.79		
TOTAL COMMITTED						32.00		
TOTAL UNENCUMBERED BALANCE				*	1,092.00*	1,254.21*	1,352.00*	*
400-407 FIELD BORDER					24,415.72	17,558.83	11,247.85	
002	2700280010	ALVIN LENGACHER	02/03/75				640.50	
001	2700280010	ALVIN LENGACHER	02/03/75				126.00	
000	2700210015	FERMAN GRABER	02/05/75			77.10		
000	2700330019	VIVIAN LOUDEN	02/27/75			1,327.20		
001	2200010006	KENNETH SCHLATTER	03/05/74		1,927.00			

DATE 10/17/75

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P.O	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
002	2200010006	KENNETH SCHLATTER	03/05/74			945.00		
000	2700280035	DON HERTIG	05/27/75			441.00		
000	2700280008	JOHN LENGACHER	05/28/74		294.00			
000	2700280008	JOHN LENGACHER	05/28/74			252.00		
000	2700280008	JOHN LENGACHER	05/28/74				231.00	
000	2700350007	JAMES C KEES	05/31/74			441.00		
000	2700270002	ROGER EHLE	06/04/74			210.00		
000	2700290009	MENNO LENGACHER	06/17/74			105.00		
000	2200010012	GILFORD DOENGES	07/02/75			252.00		
000	2700270015	EFFIE MCMAKEN	07/07/75			336.00		
000	2100080003	CHRIS ROEMKE	07/14/75			288.96		
000	2700160008	DAVID ZEHR	07/14/75			147.00		
000	2700160008	DAVID ZEHR	07/14/75				241.00	
000	2700160014	EMANUEL BRANDENBERGER	07/14/75			241.50		
000	2100050007	HELEN WEIKER	08/15/75			945.00		
000	2700300001	DAVID LENGACHER	08/18/75				234.00	
000	2700220006	KENNETH JAMES	08/26/75				378.00	
000	2700350001	JOHN FISHER	08/28/75				576.00	
000	2100050006	KENNETH HIRSCH	09/03/74			1,050.00		
000	2700200008	BEN EICHER	09/10/74			451.50		
000	2700330009	ALFRED E APPLEGATE	09/25/74			567.00		
000	2100060007	VIRGIL HIRSCH	10/02/73			441.00		
003	2700190001	JACOB J GRABER	10/16/74				357.00	
003	2200110001	WAYNE GERIG	11/04/74			231.00		
000	2700330024	NOAH LENGACHER	11/26/74			210.00		
000	2700330024	NOAH LENGACHER	11/26/74			210.00		
000	2100050010	ELMER C BOHREN	12/10/74			210.00		
TOTAL PAID					14,200.62	7,425.39		
TOTAL COMMITTED					3,142.02	9,379.86	2,783.50	
TOTAL UNENCUMBERED BALANCE				*	7,073.08*	753.58*	8,464.35*	*
400-408 FIELD WINDBREAK					104.00	138.45	147.55	
000	2700320081	ORVAL THOMAS	05/28/74			56.00		
000	2700150007	VINCE GEISTWHITE	07/12/73		80.00			
TOTAL PAID								
TOTAL COMMITTED					80.00	56.00		
TOTAL UNENCUMBERED BALANCE				*	24.00*	82.45*	147.55*	*
400-409 GRADE STABILIZATION STRUCTURES				10,850.00	48,600.00	17,627.62	12,125.00	
000	2700280010	ALVIN LENGACHER	02/03/75			480.00		
000	2700210015	FERMAN GRABER	02/05/75			607.50		
000	2700260005	RALPH THIMLAR	04/20/75			300.00		
004	2700280008	JOHN LENGACHER	05/28/74		255.00			
003	2700280008	JOHN LENGACHER	05/28/74		157.50			
000	2700350007	JAMES C KEES	05/31/74		576.00			
001	2200010012	GILFORD DOENGES	07/02/75			300.00		
002	2200010012	GILFORD DOENGES	07/02/75			75.00		
000	2700280037	KENNETH JAMES	07/14/75			309.90		
001	2700220006	KENNETH JAMES	08/26/75			900.00		
002	2700220006	KENNETH JAMES	08/26/75			82.50		
003	2700220006	KENNETH JAMES	08/26/75			24.37		
002	2700350001	JOHN FISHER	08/28/75				112.50	

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P.C	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
001	2700350001	JOHN FISHER	08/28/75				1,875.00	
000	2700280089	PAUL E KOBLE	09/15/75			60.00		
001	2100060007	VIRGIL HIRSCH	10/02/73				256.00	
TOTAL PAID				10,411.95	42,097.96	5,055.61		
TOTAL COMMITTED					988.50	3,139.27	2,243.50	
TOTAL UNENCUMBERED BALANCE				438.03*	5,513.54*	9,432.74*	9,881.50*	*
400-410 GRASSED WATERWAY OR OUTLET				5,512.44	6,265.00	19,340.06	8,772.50	
001	2700280010	ALVIN LENGACHER	02/03/75			417.12		
003	2700280010	ALVIN LENGACHER	02/03/75			160.00		
002	2700280010	ALVIN LENGACHER	02/03/75			36.00		
002	2700280010	ALVIN LENGACHER	02/03/75				36.00	
001	2700280010	ALVIN LENGACHER	02/03/75				384.00	
001	2700210015	FERMAN GRABER	02/05/75			371.04		
002	2700210015	FERMAN GRABER	02/05/75			60.00		
003	2700210003	DON A WOLF	04/01/75			240.00		
001	2700210003	DON A WOLF	04/01/75			568.52		
002	2700210003	DON A WOLF	04/01/75			160.00		
000	2700280008	JOHN LENGACHER	05/28/74			72.00		
000	2700280008	JOHN LENGACHER	05/28/74			128.16		
001	2700160012	LAVERN STEURY	06/03/75				1,248.00	
002	2700160012	LAVERN STEURY	06/03/75				300.00	
001	2700270002	ROGER EHLE	06/04/74			96.00		
002	2700270002	ROGER EHLE	06/04/74			12.00		
002	2700290009	MENNO LENGACHER	06/17/74			60.00	*	
001	2700290009	MENNO LENGACHER	06/17/74			96.00		
002	2700160008	DAVID ZEHR	07/14/75				60.00	
001	2700160008	DAVID ZEHR	07/14/75				192.00	
001	2700160009	VICTOR SCHMUCKER	07/14/73				1,008.00	
002	2700160009	VICTOR SCHMUCKER	07/14/75				72.00	
000	2700160010	PERRY E POISEL	07/14/75			18.00		
001	2700160014	EMANUEL BRANDENBERGER	07/14/75			288.00		
002	2700160014	EMANUEL BRANDENBERGER	07/14/75			60.00		
001	2700300001	DAVID LENGACHER	08/18/75			792.72		
002	2700300001	DAVID LENGACHER	08/18/75			135.00		
003	2700300001	DAVID LENGACHER	08/18/75			180.00		
002	2700350001	JOHN FISHER	08/28/75				120.00	
001	2700350001	JOHN FISHER	08/28/75				384.00	
001	2700290013	FOGLE BROTHERS	09/02/75			336.00		
002	2700290013	FOGLE BROTHERS	09/02/75			60.00		
000	2100050006	KENNETH HIRSCH	09/03/74			1,440.00		
001	2700280089	PAUL E KOBLE	09/15/75			94.50		
002	2700280089	PAUL E KOBLE	09/15/75			13.50		
000	2100060007	VIRGIL HIRSCH	10/02/73				108.00	
001	2700190001	JACOB J GRABER	10/16/74			960.00		
002	2700190001	JACOB J GRABER	10/16/74			180.00		
TOTAL PAID				5,512.44	5,454.00	10,444.25		
TOTAL COMMITTED						7,034.56	3,912.00	
TOTAL UNENCUMBERED BALANCE				*	810.92*	1,861.25*	4,860.50*	*
400-411 HOLDING PONDS & TANKS					19,020.00	12,460.00	8,568.00	
000	2200020014	JUANITA E LAKE	01/02/74				2,800.00	

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000	2700300002	CHRISTIAN GRABER	03/04/74		2,800.00			
000	0221001117	GENE FUELLING	05/08/74		2,800.00			
000	2700270002	ROGER EHLE	06/04/74			2,800.00		
TOTAL PAID					11,111.08	2,800.00		
TOTAL COMMITTED					5,600.00	2,800.00	2,800.00	
TOTAL UNENCUMBERED BALANCE				*	2,308.92*	6,860.00*	5,760.00*	*
400-413 LIVESTOCK EXCLUSION				3,235.00	4,633.60	12,727.30	11,449.10	
000	2100080003	CHRIS ROENKE	01/02/74		179.20			
000	2100080003	CHRIS ROENKE	01/02/74			307.20		
000	2700160019	DENNIS A BENNETT	01/02/74				403.20	
000	2700350005	MARVIN STIEGLITZ	01/04/74		563.20			
000	2700210001	VICTOR SCHMUCKER	01/14/75			2,713.00		
000	2700280010	ALVIN LENGACHER	02/03/75			640.00		
000	2700300002	CHRISTIAN GRABER	03/04/74		512.00			
000	2700280008	JOHN LENGACHER	05/28/74		416.00			
000	2700160012	LAVERN STEURY	06/03/75			832.00		
000	M1	JOSEPH R GRABER	06/28/74			384.00		
000	M2	JOSEPH R GRABER	06/28/74			384.00		
000	2700150007	VINCE GEISTWHITE	07/12/73			384.00		
000	2700160006	VICTOR LENGACHER	08/12/75			896.00		
000	2700160008	DAVID ZEHR	08/12/75			230.40		
000	2700160012	LAVERN STEURY	08/12/75			832.00		
000	2700210002	AMOS LENGACHER	08/12/75			384.00		
000	2100050006	KENNETH HIRSCH	09/03/74			512.00		
000	2700200008	BEN EICHER	09/10/74		640.00			
000	2700190001	JACOB J GRABER	10/16/74		352.00			
000	2700190001	JACOB J GRABER	10/16/74			352.00		
000	2100050010	ELMER C BOHREN	12/10/74			704.00		
TOTAL PAID				2,444.80	1,971.20	207.90		
TOTAL COMMITTED					2,662.40	9,554.60	403.20	
TOTAL UNENCUMBERED BALANCE				790.20*	*	2,964.80*	11,045.90*	*
400-414 LIVESTOCK WATERING FACILITY				760.00	1,150.00	670.00	1,060.00	
000	2700280010	ALVIN LENGACHER	02/03/75				210.00	
000	2700300002	CHRISTIAN GRABER	03/04/74		210.00			
000	2200020009	JESSE GRABER	06/24/74			210.00		
000	2700190001	JACOB J GRABER	10/16/74			210.00		
000	2100050010	ELMER C BOHREN	12/10/74		210.00			
TOTAL PAID				420.00	409.50			
TOTAL COMMITTED					420.00	420.00	210.00	
TOTAL UNENCUMBERED BALANCE				340.00*	320.50*	250.00*	850.00*	*
400-415 MINIMUM TILLAGE				67.50	5,122.90	9,501.10	7,980.10	6,700.00
000	2100080003	CHRIS ROENKE	01/02/74					36.40
001	2100080005	HERBERT WOEBBEKING	01/02/74			26.00		
001	2100080005	HERBERT WOEBBEKING	01/02/74				26.00	
001	2100080005	HERBERT WOEBBEKING	01/02/74					26.00
002	2100080005	HERBERT WOEBBEKING	01/02/74					46.80
001	2200020014	JUANITA E LAKE	01/02/74			72.80		
002	2200020014	JUANITA E LAKE	01/02/74				150.80	

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003	2200020014	JUANITA E LAKE	01/02/74					223.60
000	2700260012	ALFRED ROENKE	01/24/75				159.60	
000	2700260012	ALFRED ROENKE	01/24/75					159.60
000	2700330019	VIVIAN LOUDEN	02/27/75				132.30	
000	2700330019	VIVIAN LOUDEN	02/27/75					132.30
000	2200010006	KENNETH SCHLATTER	03/05/74				1,040.00	
003	2200010006	KENNETH SCHLATTER	03/05/74					1,040.00
000	2700210003	DON A WOLF	04/01/75				268.80	
000	2700210003	DON A WOLF	04/01/75					268.80
000	2200020003	MARGUERITA YODER	05/07/74			280.80		
000	2200020003	MARGUERITA YODER	05/07/74				280.80	
000	2200020003	MARGUERITA YODER	05/07/74					280.80
000	2200020005	DELBERT DELAGRANGE	05/07/74				156.00	
000	2200020005	DELBERT DELAGRANGE	05/07/74					156.00
000	2200020015	FRANKLYN WADE	05/07/74			20.80		
000	2200020015	FRANKLYN WADE	05/07/74				20.80	
000	2200020015	FRANKLYN WADE	05/07/74					20.80
000	2200020018	HARRIETT DANIELS	05/07/74			150.80		
003	2200020018	HARRIETT DANIELS	05/07/74				150.80	
000	2200020018	HARRIETT DANIELS	05/07/74					150.80
000	0221001117	GENE FUELLING	05/08/74				260.00	
000	0221001117	GENE FUELLING	05/08/74					260.00
000	2200010018	RAY GERIG	06/03/74			176.80		
000	2200010018	RAY GERIG	06/03/74				176.80	
000	2200010018	RAY GERIG	06/03/74					176.80
000	2700320001	KENNETH AMSTUTZ	06/03/74			130.00		
000	2700320001	KENNETH AMSTUTZ	06/03/74				130.00	
000	2700320001	KENNETH AMSTUTZ	06/03/74					130.00
000	2200010005	HERBERT GERIG	07/29/74				208.00	
000	2200010005	HERBERT GERIG	07/29/74					208.00
000	2100050007	HELEN WEIKER	08/15/75				90.30	
000	2100050007	HELEN WEIKER	08/15/75					90.30
000	2200010014	PAUL KORTE	08/27/74			572.00		
000	2200010014	PAUL KORTE	08/27/74				572.00	
000	2200010014	PAUL KORTE	08/27/74					572.00
000	2100060003	RICHARD YERKS	08/31/73			629.20		
000	2100060003	RICHARD YERKS	08/31/73				629.20	
000	2100060003	RICHARD YERKS	08/31/73					629.20
000	2100060014	BRUCE YERKS	08/31/73			119.60		
000	2100060014	BRUCE YERKS	08/31/73				119.60	
000	2100060014	BRUCE YERKS	08/31/73					119.60
000	2700350008	LOIS DEAN	10/24/74			104.00		
003	2700350008	LOIS DEAN	10/24/74				104.00	
000	2700350008	LOIS DEAN	10/24/74					104.00
003	2200020019	PAUL AMSTUTZ	10/31/74			260.00		
000	2200020019	PAUL AMSTUTZ	10/31/74				260.00	
000	2200020019	PAUL AMSTUTZ	10/31/74					260.00
000	2200110001	WAYNE GERIG	11/04/74			182.00		
000	2200110001	WAYNE GERIG	11/04/74				182.00	
000	2200110001	WAYNE GERIG	11/04/74					182.00
003	2200120006	DALE GERIG	11/04/74			525.20		
000	2200120006	DALE GERIG	11/04/74				525.20	
000	2200120006	DALE GERIG	11/04/74					525.20
TOTAL PAID					46.80	577.20		

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TOTAL COMMITTED						3,250.00	5,643.00	5,799.00
TOTAL UNENCUMBIRED BALANCE				67.50*	5,076.10*	5,673.90*	2,337.10*	901.00*
400-416 PASTURE & HAYLAND MANAGEMENT					620.10	1,573.10	1,378.40	1,131.80
000	2100080003	CHRIS ROEMKE	01/02/74				15.10	
000	2100080005	HERBERT WOEBBEKING	01/02/74				58.50	
000	2200020014	JUANITA E LAKE	01/02/74			23.40		
001	2700160019	DENNIS A BENNETT	01/02/74				35.10	
002	2700160019	DENNIS A BENNETT	01/02/74					58.50
000	2700230005	BILL SMITH	01/02/75			23.40		
000	2700350005	MARVIN STIEGLITZ	01/04/74		117.00			
000	2700210001	VICTOR SCHMUCKER	01/14/75			105.30		
000	2700210001	VICTOR SCHMUCKER	01/14/75					105.30
000	2700280010	ALVIN LENGACHER	02/03/75			140.40		
000	2700280010	ALVIN LENGACHER	02/03/75					140.40
000	2700300002	CHRISTIAN GRABER	03/04/74				175.50	
000	2700300002	CHRISTIAN GRABER	03/04/74					128.70
000	16	EZRA LENGACHER	04/17/74				11.70	
000	2700280008	JOHN LENGACHER	05/28/74		140.40			
000	2700280008	JOHN LENGACHER	05/28/74					128.70
000	2700290009	MENNO LENGACHER	06/17/74				128.70	
000	2200020009	JESSE GRABER	06/24/74			292.50		
000	2200020009	JESSE GRABER	06/24/74				140.40	
000	2200020009	JESSE GRABER	06/24/74					105.30
000	MI	JOSEPH R GRABER	06/28/74				362.70	
001	2700290004	JOSEPH R GRABER	08/03/73			175.50		
000	2200010004	MAX ARCHIBOLD	08/26/74					23.40
000	2200010004	MAX ARCHIBOLD	08/26/74					23.40
000	2200010014	PAUL KORTE	08/27/74			81.90		
001	2100050006	KENNETH HIRSCH	09/03/74			23.40		
001	2100050006	KENNETH HIRSCH	09/03/74					23.40
002	2100050006	KENNETH HIRSCH	09/03/74					51.90
000	2700290032	MENNO GRABER	09/10/74			117.00		
000	2100050009	HERMAN L WOEBBEKING	10/01/74			280.80		
000	2700190001	JACOB J GRABER	10/16/74			71.40		
000	2700190001	JACOB J GRABER	10/16/74					178.50
000	2700290046	MR & MRS GAY MARTIN	11/06/73			90.00		
000	2100050010	ELMER C BOHREN	12/10/74			47.60		
000	2100050010	ELMER C BOHREN	12/10/74					47.60
TOTAL PAID					362.70			
TOTAL COMMITTED					257.40	1,472.60	927.70	1,015.10
TOTAL UNENCUMBERED BALANCE				*	*	100.50*	450.70*	116.70*
400-417 PASTURE & HAYLAND PLANTING					2,548.00	9,101.50	8,871.00	2,275.00
000	2100080003	CHRIS ROEMKE	01/02/74		147.00			
001	2700160019	DENNIS A BENNETT	01/02/74		147.00			
002	2700160019	DENNIS A BENNETT	01/02/74				245.00	
000	2700210001	VICTOR SCHMUCKER	01/14/75				1,470.00	
000	2700280010	ALVIN LENGACHER	02/03/75				490.00	
000	2700280010	ALVIN LENGACHER	02/03/75					490.00
000	2700300002	CHRISTIAN GRABER	03/04/74		735.00			
000	2700300002	CHRISTIAN GRABER	03/04/74			539.00		
000	2700300002	CHRISTIAN GRABER	03/04/74				490.00	

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P.O	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
000	2700300002	CHRISTIAN GRABER	03/04/74					196.00
000	2700280008	JOHN LENGACHER	05/28/74				539.00	
001	2700160012	LAVERN STEURY	06/03/75			420.00		
002	2700160012	LAVERN STEURY	06/03/75				980.00	
001	2700160012	LAVERN STEURY	06/03/75				490.00	
000	2200020009	JESSE GRABER	06/24/74		147.00			
000	2200020009	JESSE GRABER	06/24/74			441.00		
000	2700290004	JOSEPH R GRABER	08/03/73		735.00			
000	2700200008	BEN EICHER	09/10/74			245.00		
000	2700290032	MENNO GRABER	09/10/74				441.00	
000	2700160010	PERRY E POISEL	09/15/75				1,225.00	
000	2700160012	LA VERN STEURY	09/15/75				490.00	
000	2700160012	LA VERN STEURY	09/15/75				980.00	
000	2700160014	EMANUEL BRANDENBERGER	09/15/75				910.00	
000	2100050009	HERMAN L WOEBBEKING	10/01/74			49.00		
000	2700190001	JACOB J GRABER	10/16/74			343.00		
TOTAL PAID					637.00	343.00		
TOTAL COMMITTED					1,911.00	2,037.00	8,750.00	686.00
TOTAL UNENCUMBERED BALANCE				*	*	6,721.50*	121.00*	1,589.00*
400-418 POND				4,250.00	12,000.00	22,750.00	24,375.00	
000	2700160019	DENNIS A BENNETT	01/02/74				1,800.00	
000	2700300002	CHRISTIAN GRABER	03/04/74		1,440.00			
000	2200020009	JESSE GRABER	06/24/74			1,800.00		
002	2700190001	JACOB J GRABER	10/16/74			52.50		
001	2700190001	JACOB J GRABER	10/16/74			1,800.00		
TOTAL PAID				2,814.48	6,093.58	1,919.60		
TOTAL COMMITTED					1,440.00	3,652.50	1,800.00	
TOTAL UNENCUMBERED BALANCE				1,435.52*	4,466.42*	17,177.90*	22,575.00*	*
400-420 RECREATION AREA IMPROVEMENT				374.29	1,015.71	820.00	350.00	
000	2100080005	HERBERT WOEBBEKING	01/02/74		100.00			
000	2100080003	CHRIS ROEMKE	02/01/74		200.00			
000	2700280035	DON HERTIG	05/27/75			375.00		
000	2200020009	JESSE GRABER	06/24/74			100.00		
000	2100060003	RICHARD YERKS	08/31/73		500.00			
000	2700190001	JACOB J GRABER	10/16/74			50.00		
000	2100050010	ELMER C JOHREN	12/10/74			150.00		
TOTAL PAID				374.29	75.00			
TOTAL COMMITTED					800.00	675.00		
TOTAL UNENCUMBERED BALANCE				*	140.71*	145.00*	350.00*	*
400-421 SEDIMENT CONTROL BASIN				10,317.03		3,307.43		
000	2100080003	CHRIS ROEMKE	05/06/75			3,307.43		
TOTAL PAID				1,101.03				
TOTAL COMMITTED						3,307.43		
TOTAL UNENCUMBERED BALANCE				9,216.00*	*	*	*	*
400-422 CONSERVATION FIELD TRIALS				74.50	725.00	725.00	725.00	725.50
000	2700270002	ROGER EHLE	06/04/74					200.00

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DATE 10/17/75

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P.O	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
000	M1	JUANITA LAKE	06/14/74					
000	M1	JUANITA LAKE	06/14/74				150.00	
000	M2	RICHARD YERKS	08/08/74					150.00
000	M2	RICHARD YERKS	08/08/74			100.00		
000	M2	RICHARD YERKS	08/08/74				100.00	
001	2700200008	BEN EICHER	09/10/74					100.00
002	2700200008	BEN EICHER	09/10/74			100.00		
002	2700200008	BEN EICHER	09/10/74			75.00		
001	2700200008	BEN EICHER	09/10/74				75.00	
002	2700200008	BEN EICHER	09/10/74				100.00	
001	2700200008	BEN EICHER	09/10/74					75.00
000	2100060007	VIRGIL HIRSCH	10/02/73					100.00
000	2100060007	VIRGIL HIRSCH	10/02/73				100.00	
TOTAL PAID								100.00
TOTAL COMMITTED					625.00	350.00	100.00	
TOTAL UNENCUMBERED BALANCE						275.00	5[illegible]5.00	725.00
				74.50*	100.00*	100.00*	100.00*	.50*
400-423 STREAM CHANNEL STABILIZATION 2								
000	2700350005	MARVIN STIEGLITZ	01/04/74	2,758.40	73,712.66	14,956.44		
000	2700280008	JOHN LENGACHER	05/28/74		3,200.00			
000	M2	JOSEPH K GRABER	06/28/74		600.00			
000	2700210002	AMOS LENGACHER	07/14/75		512.00			
TOTAL PAID						998.40		
TOTAL COMMITTED				2,758.40	69,400.66	8,167.67		
TOTAL UNENCUMBERED BALANCE					4,312.00	998.40		
				*	*	5,790.37*	*	*
400-424 STREAMBANK PROTECTION								
000	2700350005	MARVIN STIEGLITZ	01/04/74	3,972.50	42,282.50	15,374.50	11,943.00	
000	2700280008	JOHN LENGACHER	05/28/74		3,718.75			
TOTAL PAID					262.50			
TOTAL COMMITTED				3,972.50	34,616.92	1,590.71		
TOTAL UNENCUMBERED BALANCE					3,981.25			
				*	3,604.33*	13,783.79*	11,943.00*	*
400-426 SURFACE DRAINS								
000	2200020009	JESSE GRABER	06/24/74	780.00	6,273.15	8,364.20	5,112.65	
000	2100050006	KENNETH HIRSCH	09/03/74		350.00			
TOTAL PAID						875.00		
TOTAL COMMITTED					105.00	12.60		
TOTAL UNENCUMBERED BALANCE					350.00	875.00		
				780.00*	5,818.15*	7,476.60*	5,112.65*	*
400-427 TERRACES, GRADIENT								
000	2700280010	ALVIN LENGACHER	02/03/75		476.45	635.70	675.35	
TOTAL PAID							64.00	
TOTAL COMMITTED								
TOTAL UNENCUMBERED BALANCE							64.00	
				*	476.45*	635.70*	611.35*	*
400-428 TERRACES, PARALLEL								
000	2700200008	BEN EICHER	09/10/74		1,430.00	4,678.68	2,026.05	
TOTAL PAID						5,757.00		
					1,18[illegible].67			

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P-D	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
		TOTAL COMMITTED				5,757.00		
		TOTAL UNENCUMBERED BALANCE		*	241.33*	921.68*	2,026.05*	*
400-429 TILE DRAINS				16,408.77	2,373.70	42,725.75	5,410.00	
002	2700210001	VICTOR SCHMUCKER	01/14/75			70.00		
000	2700280010	ALVIN LENGACHER	02/03/75			504.00		
000	2700210015	FERMAN GRABER	02/05/75			105.00		
000	2700210003	DON A WOLF	04/01/75			1,419.60		
002	2200020009	JESSE GRABER	06/24/74		420.00			
000	610	UPPER WERTZ GROUP	07/14/75			180.00		
000	2700160014	EMANUEL BRANDENBERGER	08/12/75			210.00		
000	2700350001	JOHN FISHER	08/28/75				1,260.00	
000	2100060007	VIRGIL HIRSCH	10/02/73				84.00	
		TOTAL PAID		16,408.77	1,953.70	26,004.58		
		TOTAL COMMITTED			420.00	2,488.60	1,344.00	
		TOTAL UNENCUMBERED BALANCE		*	*	14,232.57*	4,066.00*	*
400-430 TREE PLANTING					156.00	208.00	156.00	
000	2700280010	ALVIN LENGACHER	02/03/75			160.00		
000	2700340008	WILLIAM YERKS	10/24/74				64.00	
		TOTAL PAID						
		TOTAL COMMITTED				160.00	64.00	
		TOTAL UNENCUMBERED BALANCE		*	156.00*	48.00*	92.00*	*
400-431 WILDLIFE HABITAT MANAGEMENT					1,684.50	3,594.50	3,822.00	1,000.00
002	2100080003	CHRIS HOENKE	01/02/74			5[illegible].00		
001	2100080005	HERBERT WOEBBEKING	01/02/74		91.00			
000	2100080005	HERBERT WOEBBEKING	01/02/74			[illegible]5.50		
002	2100080005	HERBERT WOEBBEKING	01/02/74			5[illegible].00		
004	2100080005	HERBERT WOEBBEKING	01/02/74			52.00		
000	2200020014	JUANITA E LAKE	01/02/74		10.40			
002	2700160019	DENNIS A BENNETT	01/02/74				11.38	
001	2700160019	DENNIS A BENNETT	01/02/74				52.00	
000	2700160019	DENNIS A BENNETT	01/02/74				91.00	
002	2700230005	BILL SMITH	01/02/75			52.00		
004	2700230005	BILL SMITH	01/02/75			22.75		
003	2700230005	BILL SMITH	01/02/75			26.00		
000	2700210001	VICTOR SCHMUCKER	01/14/75			11.38		
000	2700280010	ALVIN LENGACHER	02/03/75					52.00
000	2700150007	VINCE GEISTWHITE	07/12/73		22.75			
001	2200010004	MAX ARCHTBOLD	08/26/74		91.00			
000	2700190001	JACOB J GRABER	10/16/74				56.00	
000	2700290046	MR & MRS GAY MARTIN	11/06/73		74.75			
		TOTAL PAID			1,054.37	65.00		
		TOTAL COMMITTED			149.90	313.63	210.38	52.00
		TOTAL UNENCUMBERED BALANCE		*	480.23*	3,215.87*	3,611.62*	948.00*
400-432 WOODLAND IMPROVED HARVESTING				195.00	390.00	721.50	643.50	
000	2700290013	FOGLE BROTHERS	01/03/74			390.00		
000	2700210003	DON A WOLF	04/01/75				146.25	
000	2100060003	RICHARD YERKS	08/31/73		195.00			

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P.O	KEY NO	ARTICLES OR SERVICES	P.O. DATE	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
TOTAL PAID								
TOTAL COMMITTED					195.00	390.00	146.25	
TOTAL UNENCUMBERED BALANCE				195.00*	195.00*	331.50*	497.25*	
400-433 WOODLAND IMPROVEMENT				260.00	1,859.00	2,821.00	2,490.00	500.00
000	2700290013	FOGLE BROTHERS	01/03/74			640.00		
000	2700210003	DON A WOLF	04/01/75				240.00	
000	2100060003	RICHARD YERKS	08/31/73		320.00			
000	2700190001	JACOB J GRABER	10/16/74				80.00	
000	2700190001	JACOB J GRABER	10/16/74					80.00
TOTAL PAID								
TOTAL COMMITTED					320.00	640.00	320.00	80.00
TOTAL UNENCUMBERED BALANCE				260.00*	1,539.00*	2,181.00*	2,170.00*	420.00*
400-434 WOODLAND PRUNING					45.00	598.50	331.50	
000	2100060003	RICHARD YERKS	08/31/73			480.00		
000	2100060014	BRUCE YERKS	08/31/73			72.00		
TOTAL PAID								
TOTAL COMMITTED						552.00		
TOTAL UNENCUMBERED BALANCE				*	45.00*	46.50*	331.50*	*

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SYNOPSIS OF THE RED CLAY PROJECT

by

Stephen C. Andrews*

ABSTRACT

The work plan is the final report on the first or planning phase of a research and demonstration grant from the United States Environmental Protection Agency (G005140-01) under Section 108 of Public Law 92-500 (1972 Amendments to the Water Pollution Control Act) to the Soil & Water Conservation Districts of Ashland, Bayfield, Douglas and Iron Counties in Wisconsin and Carlton County in Minnesota. The intent of this project is to evaluate various structural and non-structural methods and techniques of controlling erosion and sedimentation, which will cause an improvement of water quality in area streams and ultimately Lake Superior.

The work plan is the result of evaluations and surveys conducted in the "Red Clay" area of Wisconsin and Minnesota. The surveys for Carlton County, Minnesota and the Wisconsin Counties of Bayfield, Douglas and Iron were performed under a contract between the U.S.D.A., Soil Conservation Service and the Sponsors. The Lake Superior shoreline evaluations were the result of a subcontract between Ashland County, Wisconsin and Dr. Tuncer Edil of the Civil Engineering Department of the University of Wisconsin, Madison. The Extension Service of the University of Wisconsin and the University of Minnesota were responsible for the formulation of the Inventory and Evaluation program.

The grant proposal, as submitted to the U.S.E.P.A., outlined a planning phase which called for surveys and evaluations by the Soil Conservation Service leading to the selection of specific sites within target watersheds that would be appropriate for assessment of the various recommended techniques. Concurrently, Dr. Edil was to identify sites and techniques along the Lake Superior shoreline in Ashland County for further study.

The proposal also called for the development of an information and education program which would provide forums and formats for the dissemination and feedback of information, attitudes and concepts concerning all phases of the project.

In addition, the proposal indicated a need for the identification of institutional roles and responsibilities

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*Director, Western Lake Superior Basin Erosion and Sediment Control Program, Superior, Wisconsin.

necessary to conduct not only the implementation phase but for work to be accomplished beyond the life of the project.

These work elements have been accomplished and are discussed in further detail in the work plan.

It is felt that the project will generate useful information and demonstrate viable techniques that will be applicable to other areas regarding:

1. Cost-effective and environmentally compatible methods of enhancing water quality through erosion and sedimentation control.

2. Protection of our valuable water resources as well as those of land.

3. Cooperative management techniques for planning and implementation of similar projects.

SYNOPSIS OF THE RED CLAY PROJECT

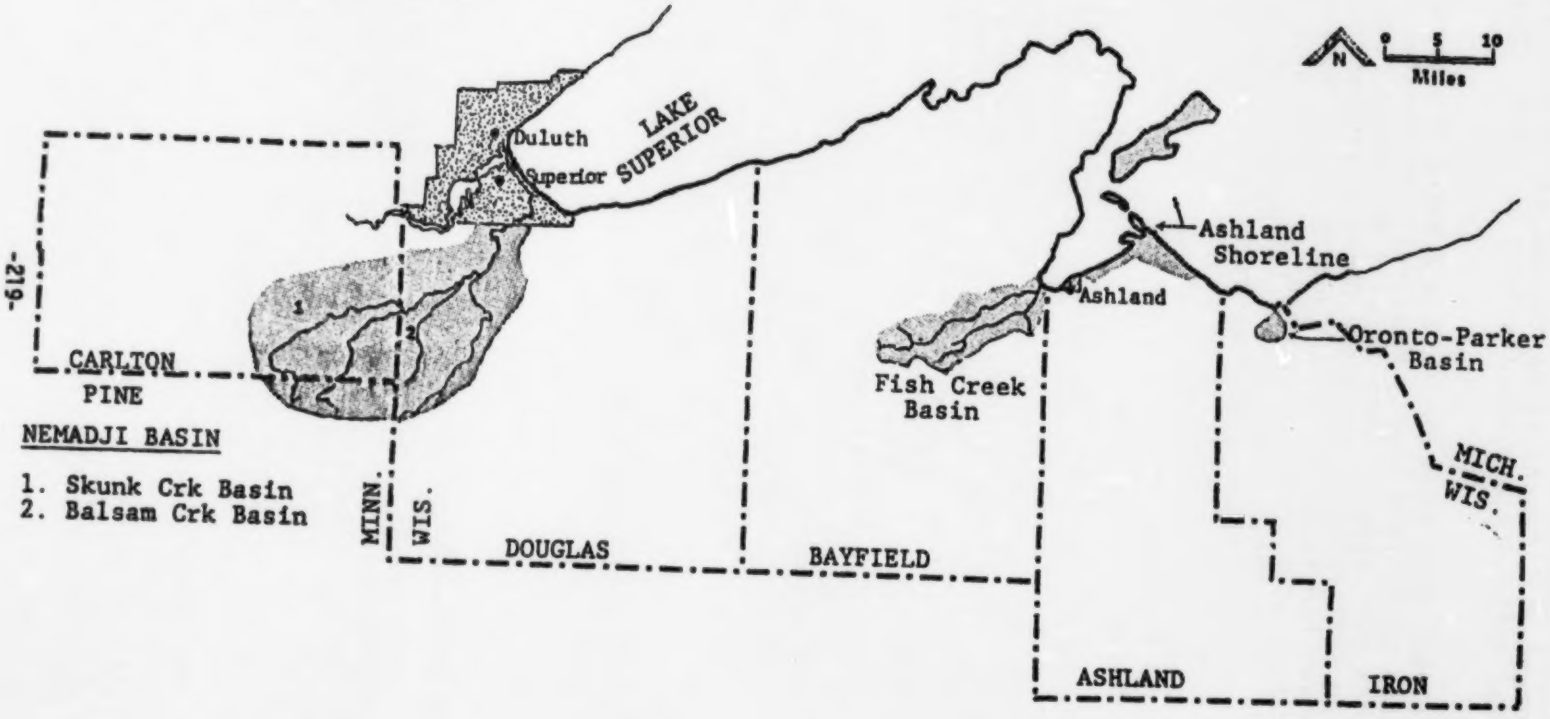
The peculiar qualities of the red clay soils on the South Shore of Lake Superior have puzzeled residents since the first white settlers arrived. Road building was difficult and the harvest of forest products was costly. Those who tilled the soil found the red clay to be surprisingly productive but very difficult to manage. Railroad engineers found long trestles and much piling needed to span the V shaped valleys of the South Shore Streams.

But it was in the mid 1950's that the first systematic research on land use problems of the red clay soils of Northwestern Wisconsin was begun. Early efforts were aimed at stabilizing streambanks, and reducing roadside erosion to cut down on the sedimentation in lakes and streams. Techniques such as mulching, vegetative covers, and erosion control structures were demonstrated.

State and Federal agencies with the help of local civic groups and private industry teamed up to study the problem. An Interagency Red Clay Committee consisting of the Soil Conservation Service, the Wisconsin Department of Natural Resources, the University of Wisconsin College of Agriculture, and the Wisconsin Department of Transportation was organized to carry out the research.

While sedimentation of the streams and lakes has long been of concern, it was not until about 1970 that the suspended clay was considered a pollutant. The first Lake Superior Water Quality Conference, called to focus on the taconite tailings situation on the North Shore, was the occasion at which the public was made aware of the nutrients entering the lake through erosion. When the finger was pointed at the South Shore, Governor Lucey order the Red Clay

RED CLAY PROJECT
Location Map



Interagency Committee to study the situation. The committee was charged with inventorying the extent of the sedimentation and outlining a plan of action to reduce this pollution.

At this same time the Soil and Water Conservation Districts in Douglas County Wisconsin and Carlton County Minnesota had begun to meet jointly to consider ways of reducing sedimentation from the Nemadji watershed. The City of Cloquet had secured E.P.A. funding for a waterline in cooperation with the City of Superior. This $8.4 million project which takes water from Lake Superior experienced a water quality problem with high turbidity resulting from resuspension of clay deposits by wave action. The Soil and Water Conservation Districts with help from the Northwest Wisconsin Regional Planning Commission developed proposals for studying the problem.

Meanwhile the Soil and Water Conservation Districts responded to the report of the Red Clay Interagency Committee by accepting responsibility for developing a program to reduce red clay sedimentation. The Lake Superior Division of the Pri-Ru-Ta Resource Conservation and Development Project District agreed to team up with the Carlton County Soil and Water Conservation District to develop project proposals.

During these planning efforts the Wisconsin State Board of Soil and Water Conservation Districts had been assisting the local districts. In June of 1973 the State Board was instrumental in arranging a tour of the five counties by representatives from the Chicago office of the United States Environmental Protection Agency. Because this agency was already involved with water quality problems at the Head of the Lakes, they were very interested in the Red Clay project proposals. It was with the continued encouragement of U.S.E.P.A. officials that the subsequent proposals were developed.

WORK PLAN

Skunk Creek Study Area

Skunk Creek, a Nemadji River tributary, is located in the eastern portion of Carlton County Minnesota. It is approximately 6900 acres of which 73% is forest land, 16% cropland, 7% is pasture and the remaining is in miscellaneous use. The soils are; clay in the eastern downstream portion, sands in the central portion and glacial tills with some outwash plains in the western area.

The Skunk Creek Study Area was selected to demonstrate sediment reduction and improved water quality through the application of structural erosion control measures. This will probably include flood retarding structures, grade stabilization structures, ripraping of channel banks, installation of drains on slopes.

At the same time we will attempt to provide 100% upland treatment within the Skunk Creek Basin.

At the present, the Onanegozie RC&D has a work plan for the roadside erosion control work needed in the basin and they will continue that program to completion independent of the Red Clay Project.

In the Skunk Creek study area research is proposed which will:

1. Identify the effects of erosion control measures on aquatic life. This will be accomplished by monitoring fish and aquatic insect population at selected sites above and below areas slated for bank stabilization.

2. Provide a picture of present and historical vegetative cover patterns which, when related to run-off data should identify the most effective vegetative cover for controlling erosion. This will be accomplished by examination of historical records, ground truthing of existing aerial photographs, identification of vegetational composition of the study area.

3. Identify the role of plant roots in retarding or acceleration of erosion. This will be accomplished by monitoring and evaluating erosion areas and correlation of root distribution patterns along established transects.

4. Provide evidence that ground water flow may be causing or aggrevating soil instability. This will be accomplished by the carrying out of ground water studies by the United States Geological Survey.

Water quality and sediment monitoring is planned at three sites in the basin. Two class "A" stations and one class "B" station are being installed by the U.S.G.S. at locations which will effectively monitor our activities.

The study of soil carried by runoff water requires a high density of precipitation measurements with useful resolution of rate over the dynamic range to be encountered. To overcome this problem, a low cost recording intensity of rainfall gauge coupled with a digital memory system will be installed on a one per square mile basis (15). In addition three wedge-type, total rainfall gauges will be placed in the basin for a comparison with measurement made with other gauges.

The temperature of the soil at several depths and air temperatures will be measured with silicon type sensors. Three temperature recorders will be placed in the study area.

Carlton County has a long history of cooperation with the RC&D and A.S.C.S. cost-sharing programs and they have given us support at every point where necessary. The Soil & Water Conservation District requested and received from the County a committment of $45,000 and six man years. The County is also seeking $120,000 from the State of Minnesota Natural Resources Commission. The receipt of these funds is somewhat tentative at this time although the County has received a favorable response on its application.

Little Balsam Creek Study Area

Little Balsam Creek, another Nemadji River tributary is located in west-central Douglas County Wisconsin. It is approximately 3,500 acres of which 88% is woodland, 5% cropland, 5% open idle land and 2% pastured woodland. The soils are represented by tills and general moraine in the southern portion, beach deposits in the central and red lacustrine clays in the northern portion.

In the Little Balsam Creek study area research is proposed which will:

1. Identify the effects of erosion control measures on aquatic life. This will be accomplished by monitoring fish and aquatic insect population at selected sites above and below areas slated for bank stabilization.

2. Provide a picture of present and historical vegetative cover patterns which, when related to runoff data should identify the most effective vegetative cover for controlling erosion. This will be accomplished by examination of historical records, ground truthing of existing aerial photographs, identification of vegetational composition of the study area.

3. Identify the role of plant roots in retarding or acceleration of erosion. This will be accomplished by monitoring and evaluating erosion areas and correlation of root distribution patterns along established transects.

4. Provide data concerning those plants (both natural and planted) which are most effective in serving as soil moisture "pumps" and thus aiding red clay stability. This will be accomplished by monitoring weather elements, soil moisture, runoff and seepage on plots of typical vegetation types.

5. Provide an objective summary of slope conditions as they exist within the study area and assess the

condition and behavior of soils within the zone normally involved in slope failure and erosion. This will be accomplished through analysis of slope morphometry and the physical/chemical properties of sediments obtained from core samples.

The Little Balsam Creek study area was selected to demonstrate water quality improvement and sediment reduction through the application of upland treatment practices, roadside erosion control and structural control measures. To adequately monitor these works, we have planned the installation of two class "A" monitoring stations and one class "B" station.

The study of soil carried by runoff water requires a high density of precipitation measurements with useful resolution of rate over the dynamic range to be encountered. To overcome this problem, a low cost recording intensity of rainfall gauge coupled with a digital memory system will be installed on a one per square mile basis (10). In addition three wedge-type, total rainfall gauges will be placed in the basin for a comparison with measurement made with other gauges.

The temperature of the soil at several depths and air temperatures will be measured with silicon type sensors. Three temperature recorders will be placed in the study area.

Douglas County is the only area where we will be doing roadside control measures. The other counties have strong RC&D programs which cost share in the work. Douglas County however, does not participate in the RC&D program to any extent and thus has a greater roadside erosion control need. The Project will be working on approximately 27 acres, however, the County's need for work is approximately 100 acres more than we can do. During the next year, the Project intends to urge greater participation in the ongoing RC&D program. All this is not to say, that the County is not interested in the program. The County Board has committed approximately $55,000 in cash for a portion of the local share. In addition they are providing an office and act as fiscal agent for the grant.

Pine Creek Study Area

Pine Creek is a tributary of Fish Creek in Northeastern Bayfield County. It's 10,000 acres are divided equally between woodland and openland. Nearly 30% of the land is used for active cropland. As such the Pine Creek study area has the most intensive agriculture of all the study areas.

The Pine Creek study area was selected to represent the entire Fish Creek Basin shortly after the initial inventory work was completed. The preliminary studies pointed out that there was not enough money or manpower available to provide land treatment for the entire basin. The alternative was to pick a smaller, yet physically similar watershed within the Fish Creek Basin as a study area. After considering land ownership, soils, type of farm operations and land use the Pine Creek study area was selected to represent the entire Fish Creek Basin.

The Pine Creek study area was selected to show the affect of applied land treatment and land use management on sediment and erosion control.

The monitoring planned for this basin includes two class "A" stations and one class "B" station.

The study of soil carried by runoff water requires a high density of precipitation measurements with useful resolution of rate over the dynamic range to be encountered. To overcome this problem, a low cost recording intensity of rainfall gauge coupled with a digital memory system will be installed on a one per square mile basis (12). In addition three wedge-type, total rainfall gauges will be placed in the basin for a comparison with measurement made with other gauges.

The temperature of the soil at several depths and air temperatures will be measured with silicon type sensors. Three temperature recorders will be placed in the study area.

While the local share ($73,000) is primarily derived from cost-sharing on land treatment with the land owners, the County did commit $43,000 in cash to insure the Project's success in the study area. In addition, the Apostle Island's Integrated Grant has provided $10,000 to be spent in Bayfield County for Project purposes.

Ashland Shoreline Study Area

Ashland County was selected to demonstrate shoreline protective devices include ripraping and selected configurations of Longard tubes.

Early surveys of four potential sites indicated that the Indian Cemetery site on Madeline Island would be an appropriate location for ripraping. In addition to providing demonstration capability, it also will protect a valuable archeological resource. Madigan beach, about 15 miles east of the City of Ashland was chosen for the Longard tube research and demonstration area. This beach has many high erodible clay bluffs which need stabilization. The primary problem is one of waves eating out the toe of these slopes. It is felt that Longard tubes in seawall and grain configurations may be useful in stabilizing the bluffs.

Both of the sites discussed above are on land belonging to the Bad River Tribal Council. The Council has passed the necessary resolutions to allow us to use both sites for the Project. Ashland County has committed $40,000 of the $60,000 local share. Here, as in Bayfield County, The

Apostle Islands Integrated Grant has provided $10,000 to help defray local costs.

Oronto-Parker Watershed Study Area

The Oronto-Parker Watershed lies in the northern area of Iron County, Wisconsin. The watershed (11,500 acres) is predominately woodland.

This watershed was selected to demonstrate the effects of a single purpose sediment basin on sediment load and water quality.

The site originally picked for the sediment basin was on the lower reach of Oronto Creek just above its confluence with Parker Creek. Subsequent investigation showed Oronto Creek to be a very important Brown Trout spawning stream. In addition it became apparent that the U.S. Army Corps of Engineers also had long range plans for the harbor area. To overcome these two potential objections to the selected site, further investigations of the watershed were conducted to find a suitable alternative.

Spoon Creek, a tributary of Oronto Creek with a watershed of 2,000 acres was selected as being representative of the larger watershed.

Monitoring of this sediment basin will be accomplished through the installation of one class "A" monitoring station and one class "B" station.

The study of soil carried by runoff water requires a high density of precipitation measurements with useful resolution of rate over the dynamic range to be encountered. To overcome this problem, a low cost recording intensity of rainfall gauge coupled with a digital memory system will be installed on a one per square mile basis (12). In addition three wedge-type, total rainfall gauges will be placed in the basin for a comparison with measurement made with other gauges.

The temperature of the soil at several depths and air temperatures will be measured with silicon type sensors. Three temperature recorders will be placed in the study area.

INFORMATION DISSEMINATION AND EDUCATION

The success of the Project is heavily dependent on the ability of the Soil & Water Conservation Districts to assimilate the work of a number of technical agencies and institutions and to promote their recommendations throughout the local jurisdictions so as to assure full and effective implementation for demonstration purposes. The variety of suggested measures ranges from structural modifications to non-structural regulations and from prevention to control, with the overriding evaluation measure being cost-effectiveness. A highly critical element in the success of such an action-oriented program will, necessarily, be the public's understanding and acceptance of the general red clay problem, the Red Clay Project's goals and objectives as well as its specific recommendations as they are advanced.

Goals and Objectives

The broad goal, then, of the information and education program is to have a diverse group of target audiences at local, state and national levels become aware and knowledgeable of red clay erosion and sediment problems and alternate solutions to these problems as they are developed by the activities of the Red Clay Project.

In working toward this general goal, there are several key objectives which must be met. These are:

1. Increase public understanding of the problems associated with red clay soils in the region.
2. Increase public understanding of the full range of possible preventive and corrective measures for handling these problems.
3. Improve public awareness of the purpose and progress of the Wisconsin/Minnesota Western Lake Superior Basin Erosion-Sedimentation Control Project, including especially, a sensitivity to the unique demonstration points cited for each Soil & Water Conservation District's project.
4. Improve public awareness of the potential environmental and economic impacts associated with the erosion and sedimentation control program.
5. Provide forums through which the public can participate in reviewing specific aspects of the program.
6. Provide forums through which the public can participate in implementing specific program recommendations, such as land use planning and regulatory controls.

Target Clientele and Audience Groups

The complexity of the Red Clay Project demands an information and education delivery system which has the capability to effectively represent it at various local levels as well as in areas far removed from the demonstration sites. At these various levels the program must be clarified, explained to, and discussed with both public officials and private individuals and groups, professional personnel and lay people. Additionally, it will be necessary for the executors of an information and education effort to work closely with groups related both formally and informally to the overall Project and the problems it addresses.

Forums and Formats

An information and education effort for a project of this type and magnitude must draw freely from the full range of available delivery mechanisms. Six distinct types of forums and formats are indicated as follows:

1. A series of conferences, workshops, public meetings, and tours will be held throughout the lifespan of the Project. They will be devoted primarily at first to general problems and needs and changing, over time, to focus on specific problems and Project progress. The work elements listed below will be systematically coordinated with each other and with overall Project activities.

    a. A series of conferences--At least once a year, planned conferences will be held at central locations for interested technical and professional personnel at the county, multi-county, state and national level. Technical information, project progress, publications and papers will be presented at these conferences.

    b. Series of workshops--These will be primarily by basin and for local officials and interested citizens. At least two workshops per year will be held in strategic locations in the area of the Red Clay Project to provide forums for participation on Project status and review.

    c. Series of planned public meetings--At least two public informational meetings will be held each year in strategic locations within the Project area, on the problems, possible alternatives, and status of the Project.

    d. Series of planned service-club-type meetings--A speaker's packet will be prepared so the Project Director or his representative can make presentations on the Red Clay Project at service-club-type meetings when requested to do so. As the Project progresses, this packet will be kept current.

    e. Series of field tours--At least two on-site tours of each demonstration project will be held each year in the Red Clay Project area. The clientele is to include professionals and interested citizens.

2. The media--radio, TV, newspapers, and newsletters will regularly be provided with pertinent information reporting generally related issues as well as specific developments as the work of the Project progresses. In this regard, the executors of the outreach effort will be encouraged to use both their serial columns and slots as well as other media formats.

   a. Radio specials--At least two fifteen-minute radio programs will be scheduled each year to be presented on tape to each of the stations in the Project area. These tapes will deal with progress or status of the Project and can include interviews of specialists involved in the Project.

   b. TV specials (video-taped)--At least two, thirty-minute TV specials will be scheduled per year to be presented to each of the TV stations that have viewing audiences in the Project area. These also will be carefully planned and should include specialists involved in the Project and include progress in any of the demonstration areas.

   c. Newspaper specials--At least once a year, a Sunday edition special or series will be presented on the status of the Project. The specials may be timed to coincide with the completion of pertinent demonstration or research activities.

   d. TV, radio, newspaper--The Project Director and staff will keep these media informed on a regular basis of news developments on the Project. If county agents have a regular radio, newspaper column or TV slot they will also be kept informed of Project developments, so this material can be presented through the media.

   e. Newsletter special--A specific Red Clay Project Quarterly Newsletter will be developed and an appropriate mailing list established. In addition, the Project Director and staff will keep other sponsors of newsletters, such as Regional Planning Commissions and RC&D projects, informed of events for publicity to be used in their regularly scheduled newsletters.

3. Special attention will be given to the presentation of technical work progress and reports of the Project through public orientated formats such as prepared fliers and slide-tape sets.

a. Fliers (brochures)--A flier or brochure or series of brochures that describe the problems and Project objectives will be developed and appropriately disseminated.

b. Slide-tape documentary--A narrative slide presentation will be developed concerning the Red Clay Project and will be maintained and modified as changes in the Project develop. This slide set presentation can be requested by public interest groups to inform their clientele of Project development and activities.

4. The preparation and use of materials such as physical models of the Project areas, maps, and photographic representations will be accomplished in such a way as to meaningfully involve non-program related groups such as school groups and other interested organizations.

a. A three dimensional physical model--Appropriate models will be developed of each of the study areas and will include the demonstration sites and structures as they are developed. These will be mobile displays or exhibits for use at public meetings and in classrooms or window displays.

b. Illustrative maps--A set of five illustrative relief maps of the total Project will be developed with demonstration sites and structures indicated. These maps will be displayed in different selected sites of the total Project area for review by the general public.

c. Photos--Specific demonstration site projects will be illustrated through a series of photos for each basin. These photos will be used to embellish the mobile displays.

5. Soil erosion and sedimentation control programs such as the Red Clay Project are recognized as a first line defense in a broad non-point pollution control program. Under Section 108 of PL92-500, several such projects are underway in the Great Lakes Basin. A film for national distribution will be made of the Red Clay Project. This film may also include portions of other, similar, 108 projects. There are two others which may be included in the film. They are the Black Creek Watershed Project in Indiana and the Washington County Project in Wisconsin.

INSTITUTIONAL MANAGEMENT SYSTEMS

The Red Clay Project is a unique and complex demonstration program involving two states, five local units of government (S.W.C.D.'s) and several cooperating governmental agencies and non-governmental institutions. The total Project area lies within the western Lake Superior watershed basin, however, within this basin, there are five separate subwatersheds or study areas. Each of the five S.W.C.D.'s has within its geographical boundaries one of the five study areas. In addition, each of the five study areas has its own goals, objectives and demonstration activities to be performed, monitored and evaluated.

In a project of this magnitude and complexity, it is difficult to segregate the variety of activities for discussion purposes and then to reintegrate them in order to relate them back to the overall Project goals. This process, however, is crucial to the effectiveness of the research and demonstration project. To do this requires a complex institutional management system.

The management system, no matter how complex, must be clearly delineated. A full understanding is needed of the inputs from participating agencies and institutions and the operating characteristics of regulatory and implementing authorities. This understanding is essential in order to help secure the needed cooperation, to help reduce the possibility of duplication of efforts and to help prevent potential conflicts with other programs.

The institutional management section of the work plan will briefly review the legal authorities making the Project possible. It will then outline the Project goals and objectives, explain how each participating institution's activities will complete objectives which lead to the fulfillment of the Project's goals. The internal management system will be discussed to indicate how the various components of the Project fit together and the Project's goals can be achieved.

Legal Authority

Local Authority: S.W.C.D.'s which have been in existence since the mid 1930's, have been actively involved in the whole process of non-point source pollution control, including erosion and sedimentation control. The four S.W.C.D.'s in Wisconsin were created pursuant to Wisconsin Statutes 92.05 and the one S.W.C.D. in Minnesota was organized according to Minnesota Statutes 40.00. All five S.W.C.D.'s are special purpose units of state government with the legal authority to plan and implement erosion and sediment preventive and control measures within their jurisdictions (Chapter 92, Wisconsin Statutes and Chapter 40, Minnesota Statutes). As special purpose units of government, the S.W.C.D.'s are empowered with the authority to cooperate with, and enter into agreements with, other equally empowered units of government and agencies (Wisconsin Statutes 92.13, 66.30 and Minnesota Statutes 40.01, 471.59).

Federal Legislation: The first federal legislation to provide a basis for broad federal agency participation in water quality management was the temporary Water Pollution Control Act of 1948. A more comprehensive law was adopted in 1956, strengthened by the 1961 amendment and further amended and strengthened and broadened by the Water Quality Act of 1965. In 1972, Congress enacted a major landmark revision of these national water quality programs with its passage of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500).

Under these laws, federal activities for improving water quality were instigated, broadened and increased to provide a wide variety of programs including those which provide for: research programs, comprehensive basin surveys and plans for controlling water pollution, promulgation of standards of water quality for interstate waters, and enforcement actions for the abatement of pollution of interstate or navigable waters.

It was the passage of PL 92-500 which added impetus to the drive to clean up the nation's waters. This was done by placing an emphasis on strong action programs and devising viable enforcement techniques. A few of the more important provisions of this law, and those which relate to the Red Clay Project, include Sections 108, 305 and 314.

1. Title I - "Research and Related Programs", Section 108 - "Pollution Control in Great Lakes".

   This section provides authorization for the E.P.A. to enter into agreements with and provide assistance for, states or their political subdivisions to research and demonstrate new techniques for retarding or controlling pollution in the watersheds of the Great Lakes.

2. Title II - "Standards and Enforcement", Section 305 "Water Quality Inventory".

   This section provides that the states and the E.P.A. shall prepare water quality inventories which identify existing water quality problems of navigable waters, point and non-point sources of pollutants and recommended remedial programs.

3. Title III - "Standards and Enforcement", Section 314 - "Clear Lakes".

   This section provides that each state shall prepare a classification of all publicly owned lakes including procedures, processes and methods (including land use treatments) to control sources of pollutants and thereby beginning the process of restoring water quality.

Goals and Objectives

The specific activities, objectives and goals to be accomplished in the five separate study areas have been previously discussed. It has been particularly difficult to discuss these objectives and activities separately because there is a considerable amount of overlapping of activities of one research program covering more than one study area. In essence then, there are five study areas, each having its own objectives and demonstration activities; a variety of research activities with their own objectives, not necessarily related to the study area objectives in each case; several project-wide, self-contained programs with their own objectives; and finally, a set of Project goals and objectives to which all of the previously mentioned objectives and activities must be related.

The ultimate goal of the Project is to research and demonstrate methods of enhancing water quality through the use of erosion and sedimentation control techniques (structural, non-structural, institutional and managerial) on geologically young, highly unstable clay soils. The planning phase of the Project has developed five secondary project goals, each with its own set of objectives. These goals are:

Goal I: The development of recommendations and plans for S.W.C.D.'s to develop long-term, basin-wide programs for erosion and sedimentation control.

Goal II: The development of institutional arrangements for implementing basin-wide porgrams for erosion and sedimentation control.

Goal III: The implementation of cost effectiveness analyses on the techniques demonstrated during the life of the Project in order to provide a guide to S.W.C.D.'s in implementing long-term control programs.

Goal IV: The demonstration and evaluation of new or innovative techniques and methods for retarding, controlling or preventing erosion and sedimentation.

Goal V: The promotion and installation of proper land use practices consistent with the capabilities and limitations peculiar to the highly erodible red clay soils.

PARTICIPATING ORGANIZATIONS AND WORKING RELATIONSHIPS

There are numerous institutions and agencies making direct input into this Project. Additionally, there are several others supporting the Project indirectly, making contributions where possible. This section will discuss the

Project participants, their work activities and their relationship to the entire Project and other work groups.

International Organizations

International Joint Commission - (IJC): The IJC is a permanent body established by the United States and Canada to carry out the purposes of the Boundary Waters Treaty of 1909. One of the major responsibilities of the IJC is to investigate and make specific recommendations on specific problems along the common frontier referred to the IJC by the governments of the United States and Canada. The IJC has been actively studying the pollution problems in the Great Lakes (including specific studies in Lake Superior) through its Pollution from Land Use Activities Reference Group (PLUARG).

Regular communication with the IJC has been maintained by the Project. The Project Director is a Technical Specialist for "Task C" of PLUARG. "Task C" is the detailed survey of selected watersheds to determine sources of pollutants, their relative significance and the assessment of the degree of pollutant transmission to boundary waters. Additional liaison between this Project and IJC is accomplished through the regular interaction of the USEPA and the IJC.

Federal Agencies and Programs

United States Geological Survey - (USGS): The USGS will contract with the Project to do the water quality monitoring work in the Skunk Creek, Little Balsam, Pine Creek and Spoon Creek study areas.

Water quality monitoring will play an important role in evaluating the overall success of the Project as well as the success of the specific control techniques being monitored. In that all techniques will be subjected to evaluations and cost effectiveness analyses, it will be imperative to determine the actual effectiveness of specific techniques in reducing sediment load.

In Wisconsin study areas, USGS and the Project will receive assistance from the WDNR for water quality monitoring. USGS and WDNR will maintain close liaison with each other and with the Project to insure the accumulation of useful data. The data produced will be of direct use to the research being conducted in each of these study areas.

Bureau of Indian Affairs - (BIA): The two sites selected for shoreline demonstration projects are situated on land owned by the Bad River Indian tribe. The Indian tribe has been kept informed of the Project intentions and have shown an interest in the successful application of the proposed demonstration projects. The BIA has aided in securing the endorsement for these projects from the Bad River Tribal Council.

Department of the Army Corps of Engineers - (the Corps): The Corps has the responsibility for the maintenance and protection of harbors and shorelines. The Corps also is the permitting agency for any structural work that may be done in these areas.

From the onset of the Project, communication has been maintained with the Corps. When appropriate, all designs and specifications will be submitted to them for compliance with permit regulations.

USDA Soil Conservation Service - (SCS): The SCS is a federal agency which, unlike most large agencies, has close local contact with field based personnel in nearly every SWCD. This agency provides technical planning and implementation assistance to all SWCD's and furnished leadership and expertise in the development of district programs.

Although SCS is one federal agency, it is departmentalized into state, area and district units of operation. These units normally work only within their own geographical jurisdictions. For purposes of the Project, a work force of several field and supportive personnel has been assigned to work within the entire project area. This has required the coordination and cooperation of two state units, two area units and five district units within the SCS.

In that SCS works closely with the SWCD's providing technical assistance for district programs, the Project will rely heavily on them for surveys, inventories, engineering recommendations and construction standards and specifications. They will also work widely with landowners to plan for, and help implement, necessary land use practices.

In addition to the ongoing district programs throughout the Project area, SCS will provide technical work for the Project in the Skunk Creek, Little Balsam Creek, Pine Creek and Spoon Creek study areas. Their work will be concentrated on the preparation and implementation of conservation farm plans; design work and specifications for certain structural measures; and general assistance for landowner contract administration, program development and evaluation.

State Agencies and Institutions and Organizations

Wisconsin and Minnesota Departments of Natural Resources (WDNR and MDNR): The DNR's of the two states are somewhat different in organization and structure but are still functionally similar in their relationships to SWCD's. The DNR's cooperate with SWCD's and other agencies in conducting surveys and evaluations leading to wise development of watersheds. The DNR's also advise the districts and landowners on the planning, development and utilization of resources. Further, technical and some financial assistance is available to the SWCD's from the Departments for preparing plans and implementing and evaluating activities for the conservation of natural resources.

The DNR's also function as the primary regulating and permitting agencies in the two states. In this capacity, the DNR's must approve designs and specifications of all work to be done on bodies of navigable waters falling within their respective jurisdictions.

Wisconsin Board of Soil and Water Conservation Districts - (WBSWCD) and Minnesota State Soil and Water Conservation Commission (MSWCC): These two agencies have similar functions in their respective states as the parent bodies or agencies providing policy guidance and assistance to SWCD's. The WBSWCD and the MSWCC work closely with SWCD's administering certain funds to districts, coordinating district programs and securing the cooperation of various local, state and federal agencies to plan and implement SWCD programs.

The WBSWCD and the MSWCC will be working closely with the Project and its sponsoring SWCD's by acting in advisory capacities to the Project Executive Committee and the SWCD's. The WBSWCD has one full-time Project Specialist assigned to the Project, under contract; and the MSWCC will be working more closely with the Project through its reorganized and expanded staff.

Red Clay Interagency Committee - (RCIC): This organization was formed in Wisconsin in 1954 to study the problems of the red clay soils in Northwestern Wisconsin and to make recommendations for correcting these problems. The RCIC has been a loosely structured organization, but one which has provided a considerable amount of useful background data and recommendations for the Project. The RCIC meets periodically and its members play a major role in advising the Project and evaluating the Project activities.

Institutions of Higher Education: Several colleges and universities throughout the two states have been instrumental in the preparation of portions of the information dissemination and education program, the Ashland Shoreline study area program, and the planned research programs. They will also be instrumental in implementing these programs.

Those institutions participating are: the University of Wisconsin-Madison, the Center for Lake Superior Environmental Studies of the University of Wisconsin-Superior, the Sigurd Olson Institute of Northland College, the University of Minnesota-Duluth and the University of Wisconsin-Milwaukee.

These institutions also have a multitude of programs involved with water quality of the Great Lakes and to a lesser degree with erosion and sedimentation control. Close liaison will be maintained to coordinate all ongoing activities between these institutions and the Project.

University of Wisconsin-Extension - (UWEX) and University of Minnesota-Extension (UMEX): The Extension branches of the university systems are responsible for carrying on the educational function of the universities away from university campuses. They have been classified here as state institutions; however, they are complex institutions with federal (USDA) and county affiliations. Extension personnel are either state-based or area-based with state and federal funding, or they are county-based with state, federal and county funding.

County-based Extension personnel work closely with SWCD's planning and implementing the educational phases of district programs. State-based and area-based personnel add support services for the county personnel in working with SWCD's.

Both UWEX and UMEX will be working directly with the Project on the information dissemination and education program. In this capacity, they will be coordinating the efforts of all groups working on this program.

Wisconsin Department of Transportation - (WDOT): The WDOT is intricately involved with the Red Clay Project on a cooperative basis. There has been and will continue to be a mutual exchange of information and materials which will prove beneficial to both parties. Through the research and demonstrations generated by the Project, the WDOT can obtain vital information for road construction and maintenance on the erosive properties of the red clay soils. Conversely, the WDOT provides the Project with considerable material and expertise concerning roadside erosion, subsurface deposits, road construction standards and specifications, etc.

Multi-county Agencies

Northwestern Wisconsin Regional Planning and Development Commission - (NWRP&DC) and the Arrowhead Regional Development Commission - (ARDC): The service of the regional planning commission is that of advisory planning for the purpose of guiding the coordinated physical development of a multi-county region. Land use plans, transportation plans, and water and wastewater management plans are important results of regional planning commission effort. The regional planning commission typically works closely with many federal, state and local government agencies and with private individuals and groups in the region. Local planning assistance is a major and significant regional planning commission activity.

The ARDC and the NWRP&DC will continue to relate to the Project through their normal activities with sponsoring SWCD;s. Both commissions will continue to give planning, coordinative and administrative assistance to the Project. The NWRP&DC is also supplying the position for the Project Director under contract with the Project.

Resource Conservation and Development Projects - (RC&D's): Each of the districts participates in a Resource Conservation and Development programs on a local level. The Wisconsin Counties make up the Lake Superior Division of the Pri-Ru-Ta RC&D. Carlton County, Minnesota participates in the Onanegozie RC&D.

Both of the RC&D Projects were instrumental in initiating the Project and were active in the planning phase. They will continue to relate to the Project in an advisory capacity. Further, they will continue to operate in their normal fashion with their member SWCD's. The work performed by the RC&D's will be complementary to the Project's work. It is not the intent of the Project to replace these programs in any aspect. On the contrary, it is hoped that methods demonstrated by the Project may, in the long run, enhance RC&D programs.

INTERNAL MANAGEMENT SYSTEM

The Red Clay Project is sponsored at the local level by five Soil and Water Conservation Districts (SWCD's) in two states. These SWCD's have co-sponsored an application for federal funding under Section 108 PL92-500. While this application and the acceptance of the grant offer binds the SWCD's of the various counties together the suprastructure created by this bond will be guided by a constitution and by-laws which will be formulated at a later date. This constitution and by-laws will provide the basis for an internal management system for the Project. To supplement the constitution and by-laws, an operations manual will be developed which will spell out the procedures for obtaining reviews and approvals of specific work items in a timely fashion.

While these five SWCD's represent two states, their interactions with the state agencies of Wisconsin and Minnesota are similar enough that we may discuss them on a project wide level rather than on a county level. The major difference between the SWCD's in the two states is that in Wisconsin the supervisors are selected from the local county board of supervisors and in Minnesota the supervisors are elected directly. In Wisconsin, by law, the SWCD supervisors are the members of the Agriculture and Extension Committee. This system allows for greater interaction with other local units of government and their committees, but it does promote a greater reliance of the SWCD on the county boards for funding and approval of activities. In Minnesota, the system of directly electing SWCD supervisors provides for a greater autonomy on the part of the supervisors, but it does tend to lessen the direct working relationship with other local units of government.

Wisconsin Statutes 66.30 and 92.13 and Minnesota Statutes 471.59 and 40.01 permits joint exercise by SWCD's of any power as duly required of or authorized to the SWCD by statutes enable the SWCD to cooperate with other SWCD's or governmental units through intergovernmental contracts. These districts are the legally constituted authorities to carry out measures for the control and prevention of erosion and sediment damages. Soil and Water Conservation Districts, the boundaries of which in these two states coincide with county boundaries, are, for all intents and purposes, working parts of county government.

The district cooperates with landowners and occupiers in developing and implementing plans for soil erosion control, improved water management, and related objectives. The county board of supervisors, the federal Soil Conservation Service, the federal Agricultural Stabilization and Conservation Service, the University Extension Service and other state and local agencies, and private organizations collaborate with the Soil and Water Conservation Districts. In Wisconsin, the district may formulate land use regulations which, if adopted by ordinance of the county board, may require installation of various kinds of water-control structures on private lands, use of particular methods of cultivation, observance of specified cropping programs and tillage practices, retirement from cultivation of highly erosive areas, and other land management measures for conserving soil and water resources. Such land use ordinances, if adopted and enforced, could have substantial beneficial effects of improving the quality of the waters of streams and lakes. A bill to enable Minnesota districts with similar authority is pending.

Project Executive Committee

The SWCD's have joined together by agreement to sponsor the Project. In order to facilitate project-wide decision-making, they have formed a Project Executive Committee consisting of equal representation from each of the five SWCD's. As mentioned, this is the ultimate decision-making body of the Project. Each SWCD representative acts as an intermediary between the Committee and his SWCD, relating information and seeking necessary SWCD approval for decisions directly affecting his or her SWCD.

The Douglas County SWCD and its representative on the Executive Committee act as fiscal agent for the Project. In this capacity, it deals directly with the USEPA and implementing groups in all contractual and fiscal affairs.

Project Director

The Project Director, hired by NWRP&DC and furnished under contract to the Project, is responsible for overall Project operations and making day-to-day decisions guided by the policy and decisions made by the Executive Committee. His job is administrative and coordinative. Working directly with the Executive Committee and the implementing groups, his job is to interpret Executive Committee policy to the implementing groups to insure the smooth operation of the Project.

Staff Services

The Project Director has at his disposal the services of staff personnel to assist him in conducting project operations and seeing that the Project goals are met. The WBSWCD has supplied a full-time Project Specialist, under contract, to provide specified services to assist the Project Director. In addition, the Project has hired, through the Project's fiscal agent, needed secretarial services. If the financial parameters allow, there is also the potential for expanding the Project staff to include additional secretarial services, specialists, consultants, and assistants.

Advisory Bodies

During the formative and planning phases of the Project, several advisory committees and groups were in existence to advise the Executive Committee and the Project Director. These included: the Project Advisory Committee, the Technical Interagency Consortium, the Research Advisory Committee and the Information-Education Committee.

In addition, several non-project organizations and agencies were called upon for advice, assistance and planning evaluations. During the course of the implementation phase of the Project, these groups may be asked to reconvene on an ad hoc basis to assist with specific matters.

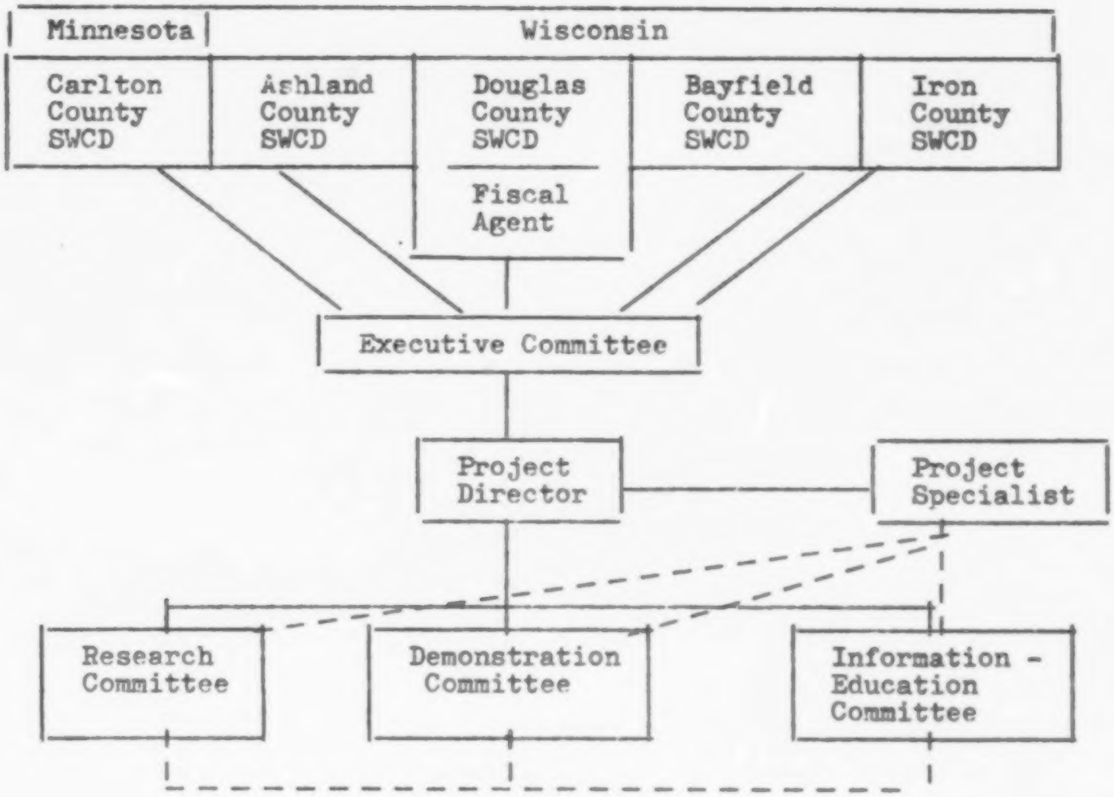
Implementing Bodies

To insure the timely implementation of Project activities and the completion of Project objectives and goals, three implementing bodies are recognized. The Research Committee, consisting of the principal investigators of contracted research activities and selected Project staff, is responsible for maintaining liaison with the Project Director, coordinating research activities, and seeing to the ultimate completion of all research aspects of the Project.

The Demonstration Committee consists of those principal investigators and Project staff responsible for the implementation of demonstration activities (i.e. structure installation, vegetative trials, land use practices, etc.). This committee will provide liaison with the Project Director, coordinate all demonstration activities, and supervise the installation of structures, trials, and practices.

The Information Dissemination and Education Committee consists of Project staff and those representatives from educational institutions responsible for information dis-

RED CLAY PROJECT
ORGANIZATIONAL STRUCTURE
and
FLOW CHART



semination and public education. As with the other committees, they will work directly with the Project Director to keep him informed, to coordinate activities and to insure the timely implementation of specific activities.

ANALYSIS AND EVALUATION METHODS

Due to the complexity of the Red Clay Project, it is difficult to discuss without repetition, the various analysis procedures and evaluation techniques as they apply to the five separate study areas and the numerous demonstration and research activities. At this point, it is sufficient to state that all field and laboratory analysis methods follow standard formats and, where applicable, are consistent with USEPA recommended guidelines.

It is important to discuss analysis and evaluation methods relating the various self-contained work elements to the Project's overall goals and objectives. While it is essential to have self-contained systems of analysis and evaluation in each of the Project's work areas, it is even more important from the standpoint of the entire Project to devise a system to analyze and evaluate the research and demonstration elements for separate activities in order to show interrelationships between them and with the Project goals. The end result of any such system, or set of systems, would be a complete evaluation of the Project, the development of systems which would be applicable to other projects and programs, the production of evaluation reports, publications and recommendations, and, ultimately, the attainment of the Project goals.

Methods of Analysis

As was mentioned in the introduction, research activities will be subject to standard analyses consistent with USEPA recommendations. The research activity is being contracted to competent institutions and individuals familiar with the standard research and analysis techniques. This standardization of techniques will insure data compatibility.

The efficacy of the demonstration activities in improving water quality will be analyzed by the USGS monitoring systems described in this plan. Their handling of all the monitoring will insure a standard system of data collection and storage for later retrieval.

The WBSWCD Project Specialist, as a Project staff member, will be responsible for working with other Project staff to analyze the numerous research and demonstration programs to relate them directly to the Project goals and objectives. This will be done through an ongoing process of program coordination and review. This type of analysis will be managerial and somewhat subjective, relying on the more objective analyses being performed in the various programs and study areas. The objectiveness of this type of analysis will be met by the reports and publications produced. These reports and publications will analyze and evaluate the programs and will contain recommendations for their potential use in erosion and sedimentation control programs to improve water quality.

The one overriding analysis to which all research and demonstration aspects of the Project will be subjected is a cost-effectiveness analysis. Through this type of an analysis, the measured results of the programs can be viewed in light of their costs. The result will be a meaningful analysis of control measures and research activities with indications as to their realistic applicability to other demonstration projects or long-term erosion and sedimentation control programs.

Methods of Evaluation

Evaluation of any program should be a continual process. This is necessary to assess current status, catch any mistakes or errors and make necessary changes in program direction and emphasis. The Red Clay Project has built into its operational structure a system of quarterly and annual review meetings as well as ad hoc meetings of the various operational committees. These will serve the dual purposes of periodically reviewing Project progress and providing the format for ongoing program evaluation.

In addition to the various review meetings, ongoing program evaluation will be accomplished by visual, photographic, research and other appropriate methods. Upland treatments in the demonstration program will be periodically evaluated visually, making use of the generally accepted Universal Soil Loss Equation method. Structural facilities in the demonstration program will be continually evaluated by visual and photographic documentation. Erosion rates within the treated areas will be compared to rates in the untreated areas. Where streambank protection and sediment traps are planned, complete land surveys will be run. A geometric comparison of existing, as-built and end-of-project conditions will be made. Sedimentation and erosion will be measured from time of construction to the end of the Project.

The Project staff, through its management system, will be responsible for all program evaluation. To assist with this, the WBSWCD Project Specialist has been hired to accomplish specific objectives regarding program evaluation. Through the processes of programs coordination, data review, supplemental academic research and technical documentation, all programs will be evaluated in terms of the Project goals. Programs will have to lend themselves to helping achieve the goals and objectives. That is, they must fit into the development of long-term, basin-wide control programs for SWCD's in a cost-effective manner, successfully demonstrate new or innovative techniques for controlling erosion and sedimentation to improve water quality, provide new data for erosion and sedimentation control on red clay soils, and/or be of value in disseminating information or educating specified audiences.

Periodic evaluations will be contained in interior publications, reports and documents. Final evaluations, of course, will be contained in the final Project report to USEPA as well as in recommendations to the sponsoring SWCD's.

EXPLANATION OF ABBREVIATIONS USED

Abbreviation	Agency, Institution or Organization
ARDC	- Arrowhead Regional Development Commission
ASCS	- Agricultural Stabilization and Conservation Service
CLSES	- Center for Lake Superior Environmental Studies (University of Wisconsin-Superior)
Corps, the	- United States Army Corps of Engineers
GLBC	- Great Lakes Basin Commission
IJC	- International Joint Commission
MDNR	- Minnesota Department of Natural Resources
MPCA	- Minnesota Pollution Control Agency
MSWCC	- Minnesota Soil and Water Conservation Commission
NACD	- National Association of Conservation Districts
NWRP&DC	- Northwestern Wisconsin Regional Planning and Development Commission
Project, the	- The Minnesota/Wisconsin Western Lake Superior Basin Erosion and Sedimentation Control Project (the Red Clay Project)
RC&D	- Resource Conservation and Development Project
RCIC	- Red Clay Interagency Committee
RP&DC's	- Regional Planning and Development Commissions
SCS	- Soil Conservation Service
SWCD	- Soil and Water Conservation District
UGLRC	- Upper Great Lakes Regional Commission
UMD	- University of Minnesota-Duluth
UMEX	- University of Minnesota-Extension
USBIA	- United States Bureau of Indian Affairs
USDA	- United States Department of Agriculture
USDI	- United States Department of the Interior
USDOC	- United States Department of Commerce
USEPA	- United States Environmental Protection Agency
USGS	- United States Geological Survey
UWEX	- University of Wisconsin-Extension
UW-Mad	- University of Wisconsin-Madison
UW-Mil	- University of Wisconsin-Milwaukee
UWS	- University of Wisconsin-Superior
WBSWCD	- Wisconsin Board of Soil and Water Conservation Districts
WDNR	- Wisconsin Department of Natural Resources
WDOT	- Wisconsin Department of Transportation

BACKGROUND, DEVELOPMENT, AND OBJECTIVES OF THE WASHINGTON COUNTY PROJECT

by

T. C. Daniel*

ABSTRACT

The primary objective of the project is to demonstrate the effectiveness of land treatment measures in improving water quality, and to devise the necessary institutional arrangements required for the preparation, acceptance and implementation of a sediment control ordinance or other management program applicable to incorporated and unincorporated areas on a county-wide basis.

The conceptualization of the project, the participation and involvement of appropriate interest groups and the development of project objectives is reviewed. Each objective is discussed with emphasis on strategies for implementation and accomplishments to date.

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Development of the Washington County Project began in April of 1973 as a result of the Governor's Conference on Sediment and Erosion Control held at Madison, Wisconsin (1). Preliminary meetings followed, identifying those organizations and agencies concerned with non-point pollution, particularly sediment. During the two year period, the list of participants in the project was expanded to include representatives of federal, state and local agencies, academic institutions, elected officials and appropriate interest groups. An executive committee representing the participants was created and charged with the responsibility of reviewing the status of the non-point pollution problem, identifying the major problems needing investigation, developing project objectives, and providing a mechanism for project implementation (Table 1). For detail concerning the organization, roles and responsibilities of the various committees involved in the project the reader is referred to the Washington County Work Plan (2).

Table 1. Organizations and Agencies Involved in the Development of the Project

Abbreviations	Organizations and Agencies
NACD	National Association of Conservation Districts
SEWRPC	Southeastern Wisconsin Regional Planning Commission
USDA-ASCS	United States Department of Agriculture - Agricultural Stabilization and Conservation Service
USDA-SCS	United States Department of Agriculture - Soil Conservation Service
US-EPA	United States - Environmental Protection Agency
USGS	United States Geological Survey
UWEX	University of Wisconsin - Extension
UW-MAD	University of Wisconsin - Madison
UW-SNR	University of Wisconsin - School of Natural Resources
UW-Soil Sci	University of Wisconsin - Department of Soil Science
UW-WRC	University of Wisconsin - Water Resources Center
WCSWCD	Washington County Soil and Water Conservation District
WDNR	Wisconsin Department of Natural Resources
WGNHS	Wisconsin Geological and Natural History Survey
WSBSWCD	Wisconsin State Board of Soil and Water Conservation Districts

The remainder of this report will provide information on the background of the project, project objectives, approaches to achieving those objectives, and project accomplishments to date.

BACKGROUND OF THE WASHINGTON COUNTY PROJECT

The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) approaches the problem of the protection and improvement of the quality of the nation's lakes and streams. The legislation is specific with respect to the types of pollution to be investigated, the mechanisms and time frame required and the agency(ies) having primary responsibility for accomplishing the control aspects of the law. In the past, the US-EPA has directed efforts towards the control of point sources of pollution and the development, revision and updating of guidelines for controlling the quality of effluent discharged from industry, municipal treatment plants and feedlots are being revised and updated to reflect advances in treatment technology. Additionally, the US-EPA is focusing attention on non-point or diffuse sources of pollution such as agricultural and urban runoff. Because of their diffuse character, these pollutional sources are more difficult to quantify and define. Undoubtedly, controlling these pollutional sources is complicated by the interrelated complexities and inherent variability in the systems involved and by the lack of backgound information required to define the problem. However, control of non-point sources is of great importance for maintaining the quality of surface waters and management methodology for minimizing their discharge must be developed.

Sediment transport and deposition is a classic example of pollution arising from a diffuse source. Nationally, sediment is by volume the single largest pollutant of the nation's surface waters. Aside from the objection to sediment from an aesthetic standpoint, deposition of sediment in surface waters can cause a degradation in water quality resulting from increases in suspended and bed loads, total dissolved solids and oxygen demand. Eutrophying and other components of the eroded material, such as readily available ortho-phosphate, soluble nitrogen and pesticides, etc. are also released as a result of the interaction between eroded soil particles and surface waters. Annually, dredging costs to keep the nation's streams and harbors open are conservatively estimated at $300 million.

Although erosion and subsequent sedimentation is a natural geological process which cannot be eliminated completely, man's activities can, and have, greatly accelerated the process. The rates of soil loss are directly related to types of land use. Sediment, with its deleterious effect on water quality, has been identified as the major pollution problem in seven of the 17 chapters describing the effect of different land use categories cataloged as potential sources of loading to the Great Lakes by a Reference Group of the U.S.-Canada International Joint Commission (3). This comprehensive review of land use in relation to pollutional loading into the surface waters of the Great Lakes clearly identifies sediment as a major pollutant and calls for new and innovative programs for its control and prevention.

The primary source of sediments polluting surface waters is agricultural and other rural lands lacking adequate conservation practices. However, a second major source of sediment is land undergoing changing use patterns as exemplified by areas of rapid urbanization (construction sites). This source comprises a major hazard because it is largely unabated and conservation practices are normally not applied during construction. Rates of erosion from urbanizing areas may exceed those from agricultural lands by factors from 100:1 to 200:1. Sediment loading into surface waters will continue to increase with time due to the increased demand for agricultural production which involves both more intensive agriculture and the cultivation of formerly idle land, and to continual urbanization and the development of previously rural lands. The land being newly brought into agricultural production is likely to be critical when evaluated in terms of its potential erosional hazard either because of the slope or shallowness of the soil.

Historically, the problem of soil loss has been viewed strictly as a rural problem controlled only for the economic benefit of the landowners. Presently, and to a greater degree in the future, deterioration in water quality arising from sediment deposition either from rural or urban areas must be viewed in light of the general public's right and desire for high quality surface water and included in this evaluation must be the downstream cost and effect of sediment deposition.

Prior investigations and experience by agencies such as the USDA-SCS have led to the development of an erosion control technology which if fully implemented will dramatically reduce soil loss from unprotected cropland and construction site areas. The major obstacle has been an inability to develop and implement programs which provide a uniformly high degree of land application of conservation practices. Prior experience has shown that the voluntary and incentive mechanisms have been successful to a point; however, these programs do not result in a uniformly high degree of implmentation of land practices. Erosion can be controlled--the problem is the development of new and innovative management programs to correct the inadequacies of a strictly voluntary-incentive program.

Solving the basic problems of implementation of conservation practices necessitates investigating the social, economic, legal and political aspects of the issue as well as the technical components. Answers to these questions can only be provided by multi-agency and interdisciplinary programs devoted to problem-oriented research and demonstration. It is only through this mechanism that a forum of exchange between those affected by management programs and the agencies (federal, state, local) required to develop and administer such programs that realistic guidelines and methods of implementation can be developed.

OBJECTIVES

As a result of input from the participants identified in Table 1 the overall objective of the program is to demonstrate the effectiveness of land treatment measures in improving water quality, and to devise the necessary institutional arrangements required for the preparation, acceptance and implementation of a sediment control ordinance or other management program applicable to incorporated and unincorporated areas on a county-wide basis. Specific objectives deemed necessary for the successful attainment of the overall objectives are:

1. Demonstrate through a monitoring program the effectiveness of sediment and erosion control techniques for improving water quality.

2. Develop a sediment control ordinance or other management mechanisms acceptable to landowners and the several governmental authorities responsible for implementing such measures and determine the combination(s) of institutional arrangements in the form of laws and intergovernmental relationships involving federal, state, county and municipal governments required for implementing management programs in incorporated and unincorporated areas on a county-wide basis.

3. Develop a model of the personnel required and the technical and financial assistance needed to implement a sediment control program.
4. Develop and systemize the educational and information dissemination effort to the general public and appropriate user groups required for implementing a sediment control program.
5. Provide an evaluation of the feasibility of implementing management programs for sediment and erosion control in the Great Lakes Basin States and other areas where applicable.

PROCEDURES FOR IMPLEMENTATION OF OBJECTIVES

Each of the objectives will be discussed individually with respect to mechanisms and procedures identified for their implementation. The purpose of this document is to provide a brief summary of major project activities. For more detailed information, the reader is referred to the Washington County Work Plan (2).

Demonstrating Improvement in Water Quality

The area of water quality vs. land use and its associated runoff necessitated clarifications especially in light of potential regulatory programs. Two watersheds, one agricultural (Kewaskum) and the other rapidly urbanizing (Germantown) were selected in Washington County, Wisconsin (Fig. 1). The Kewaskum Watershed is devoted primarily to a dairying type of agricultural enterprise. A dairy farming area was selected because dairying is the dominant type of agriculture in the Great Lakes Basin (4). The Germantown watershed has been identified as the area in Washington County scheduled for rapid development and subsequent construction activity (5). This rapid development is a result of population pressure from the nearby Milwaukee metropolitan area. Intensive water quality monitoring activiy is scheduled for the two watersheds and information will be developed on a total loading basis for selected parameters. Background information will be developed concerning runoff under present land use conditions with subsequent information collected as a result of the implementation of intensive conservation practices. Information provided from this activity will be utilized in various aspects of developing a management program, i.e., cost-benefit, background levels of pollutants, effectiveness of conservation practices on water quality, and sediment delivery ratio.

Development of a Planning and Management Program for Sediment Control

Efforts in this area focused on identifying and integrating the expertise required to work on the legal, social, political and economic aspects of the project. Problem areas will be handled by individuals whose research interests are devoted to the solution of problems of a practical, people-oriented nature. Definition of objectives and mechanisms of accomplishment have been evaluated in each discipline for the respective graduate research assistants and biweekly meetings are in progress to insure coordination. Specific analysis of existing state and local statutory authorities have been initiated. An examination of existing federal, state and local institutional arrangements and their potentials for implementing sediment control programs also has been initiated.

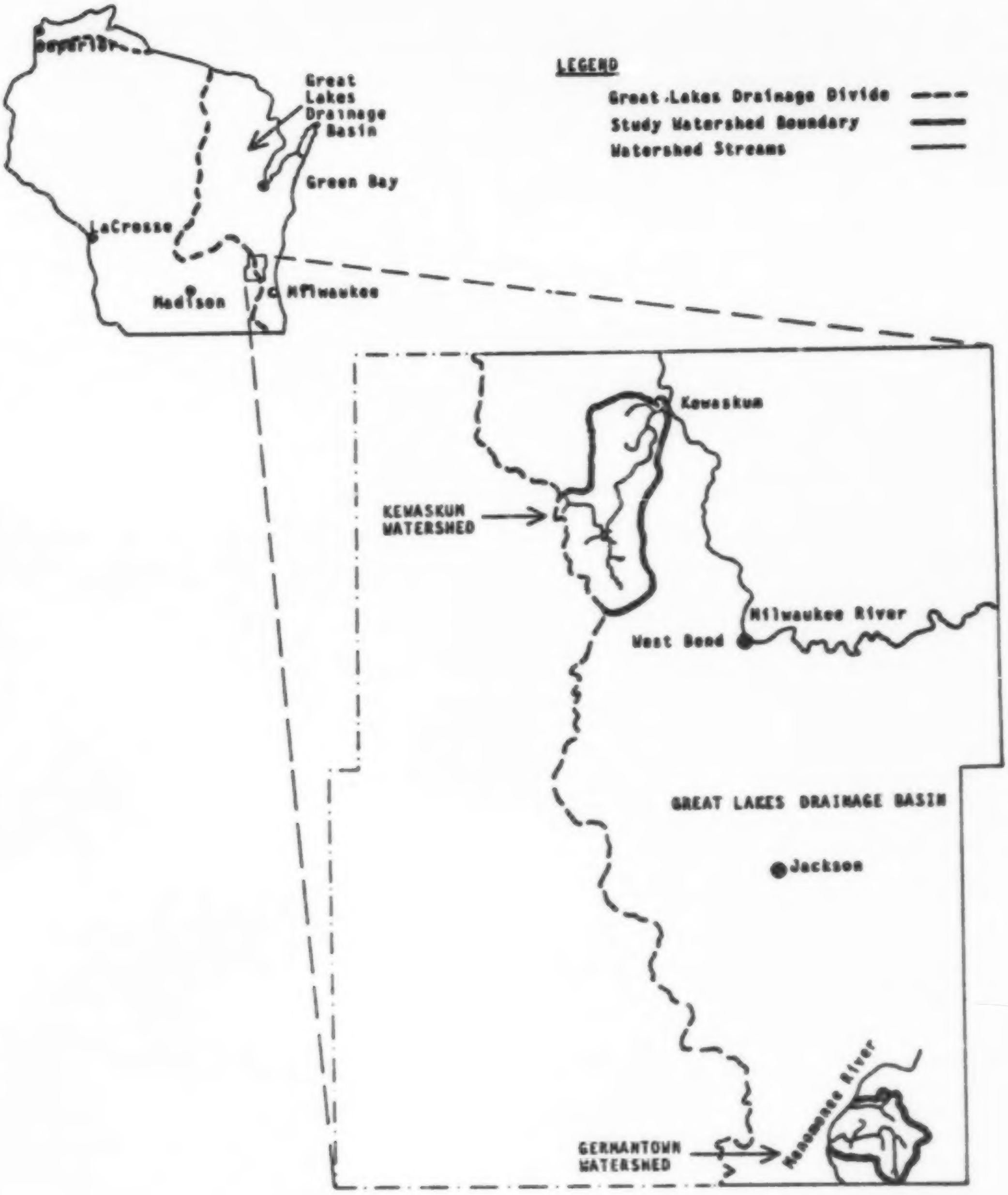

FIG. 1 Map of Washington County, Wisconsin, showing its geographical location and selected project sites in the Great Lakes Drainage Basin.

Personnel, Technical and Financial Requirements

Any management program developed will require clear identification of staff needs to implement and administer such programs. The importance of this component cannot be overlooked for, in part, it will determine the economic acceptability of the different alternatives and become increasingly more critical when the results are projected on a regional basis. The amount or level of personnel required at the local, state or regional level is less known than the type of personnel required. These activities will be accomplished in concert and concomitantly with objective 2.

Education and Information Program

Specific local audiences have been identified and informational brochures and slide sets are in various stages of development. Numerous visual aids, namely slides and film, showing the local leaders and monitoring site installations have been collected. A slide set for use in describing the project at local meetings is being developed and will be updated continually. Several informational brochures have been identified which will provide information concerning sediment effects on water quality and how the project is being structured to address the total question of nonpoint pollution for distribution to state, regional (interstate) and national audiences. The mechanism of developing appropriate brochures and visual aid materials will be a coordinated effort among several disciplines within the University of Wisconsin-Extension.

Application of Results to Other Areas

The development of a sediment control management plan for Washington County will serve as a demonstration of technical and institutional mechanisms for conducting a county-wide, rural-urban program. The demonstration must, however, achieve the goal of being implementable on a much broader geographic scale, i.e., state-wide, regional or perhaps, even national. It is fully understood that this demonstration can only serve as a prototype since other areas will have to develop programs taking into account their own unique political, legal and economic constraints. However, when utilizing Washington County as a demonstration site, part of the evaluation of the alternatives must include those programs which institutionally have the inherent ability to be projected to state, regional and national scope.

SUMMARY AND PRESENT STATUS

The project was funded in June 1975 with the Wisconsin State Board of Soil and Water Conservation Districts as the grantee and will continue through December 1978. Initially, most of the activity centered around accumulating project and support staff. Interdisciplinary groups have been established and coordination of activity initiated. Monitoring site installation will be completed and data will be available in time for the spring runoff in 1976. Many elected and public officials in Washington County have been active in all phases of the project and have taken the leadership role at the local level. Accomplishment of the objectives will be performed in concert with each other, however, little substantive activity is expected on objective 3 or 5 until the middle stages of the program.

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Summary Remarks
By
Carl D. Wilson

In summarizing todays presentations I would like to briefly review a few items that I feel are pertinent for planning consideration.

From historical data, the annual long term sediment yield from the Maumee River into Lake Erie is approximately 2,000,000 tons (1,800,000 metric tons) or, in terms of the basin, about 936 lbs/ac(105 kg/ha). The annual long term precipitation over the Maumee River Basin is around 33 inches (840 mm). Of that amount, less than one-third or around 9.4 inches (240 mm) is runoff into Lake Erie.

For the year 1974-75, the sediment yield from the Black Creek Watershed into the Maumee River was 1750 kg/ha. One major storm event in late May caused over onehalf of the sediment load.

In the Black Creek Watershed alone over 750 tile outlets have been identified. All flows contained some sediments.

Mr. Mayo has indicated his desire that soil and water conservation districts get involved and take the lead at the local level to help solve nonpoint source pollution. The Environmental Protection Agency has no intention of upsetting any Federal or state on-going programs.

To fulfill the requirements of the water bill it will have to be a cooperative effort between states and local governments.

Mr. Heitzenrater has stated that:

(1) With regard to agriculture pollution control, one of the key public decisions will be that level of technical information that is needed to justify action.

(2) It is now becoming rapidly apparent that water quality is an integral part of the American agriculture mission. The real and definite pollution threat from sediments, nutrients, and pesticides must be dealt with. The main thrust of non-point source pollution control will come from 208 areawide planning.

(3) There are two recent publications which have been released on nonpoint source pollution that will be of help to 208 planning agencies, entitled:
    (a) "Interim Report on Loading Dunctions For Assessment of Water Pollution From Nonpoint Sources", published November 1975.

(b) "Control of Water Pollution from Cropland - Volume I
Manual for Guideline Development", EPA-600/2-75-026a

Mr. Churchill has stated that:

(1) The 208 planning and management program is the central administrative vehicle for both point and nonpoint sources. We have initiated the areawide program and the governors have designated 149 planning and management agencies, and EPA has granted $150 million to finance the initial two year planning period.

(2) If it is found there are no problems there will be no programs.

From the reports of the Black Creek Project investigators it has become clear that technical assistance and financial incentives are not sufficient to convince every farmer or landowner to install needed conservation practices.

Data collected during three storms in the Black Creek Watershed in late February and mid-March has been analyzed. This preliminary data indicates that in all cases the nutrients and suspended solids transported by a stream increased with increasing flow. More importantly the nutrients and suspended solids concentrations also increase with increased flow with the exception of ammonia and nitrate whose concentrations showed very little variation during a storm event.

Farmers do not feel that they should stand the cost of soil erosion programs alone. Education is considered by landowners to be the most effective tool to get cooperation on protecting water quality.

This is a brief summary of things that immediately come to mind. I'm sure there are other important things I have left out. We thank you for your attention and participation in this seminar today.

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